# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. LI. FEBRUARY 13, 1891. No. 4


Lieut.-General J. F. TENNANT, C.I.E., R.E., F.R.S., President, in the Chair.

George Price Blackwood Hallowes, 77 Lansdowne Road, Didsbury, Manchester;
Shin Hirayama, Astronomer at Tokio Observatory, Japan;
Robert John Pearce, M.A., D.C.L., Professor of Mathematics in the University of Durham;
John Morris Stone, M.A., 29 Lee Park, Blackheath, S.E.

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:

John Billington Booth, J.P., Preston, Lancashire (proposed by Ralph Copeland);
Hannibal Mirabita, 134 Strada Britannica, Alexandria, Egypt (proposed by Rev. Joseph Reed).

## REPORT OF THE COUNCIL TO THE SEVENTY-FIRST ANNUAL GENERAL MEETING OF THE SOCIETY.

The following table shows the progress and present state of the Society:—

| | Compounders | Annual Subscribers | Mathematical Society | Total Fellows | Associates | Patron | Grand Total |
|---|---|---|---|---|---|---|---|
| December 31, 1889 ... ... | 234 | 358 | 3 | 595 | 48 | 1 | 644 |
| Since elected ... ... ... | +5 | +26 | ... | ... | +3 | ... | ... |
| Deceased ... ... ... ... | −4 | −1 | ... | ... | −3 | ... | ... |
| Resigned ... ... ... ... | ... | −4 | ... | ... | ... | ... | ... |
| Expelled ... ... ... ... | ... | −1 | ... | ... | ... | ... | ... |
| Removals ... ... ... ... | +4 | −4 | ... | ... | ... | ... | ... |
| December 31, 1890 ... ... | 239 | 374 | 3 | 616 | 48 | 1 | 665 |

*Mr. Common's Account as Treasurer of the Royal*

RECEIPTS.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Balances, January 1, 1890:— | | | | | | |
| at Bankers', as per Pass Book ... ... | 488 | 18 | 7 | | | |
| „ on Deposit Account ... ... | 500 | 0 | 0 | | | |
| in hand of Assistant Secretary on account of Turnor and Horrox Fund ... ... | 4 | 13 | 5 | | | |
| in hand of Assistant Secretary on Petty Cash Account ... ... ... ... | 6 | 4 | 6 | | | |
| | | | | 999 | 16 | 6 |
| Dividends on £13,200 Consols, 2¾ per cent. ... | 353 | 18 | 8 | | | |
| Half years' Dividends on £750 Metropolitan Stock, 3 per cent. ... ... ... ... ... | 10 | 19 | 6 | | | |
| Half-years' Dividends on £1,250 Metropolitan Stock, 3 per cent. ... ... ... ... | 18 | 5 | 8 | | | |
| Interest on £500 on deposit at Bankers' ... ... | 14 | 5 | 11 | | | |
| | | | | 397 | 9 | 9 |
| Received on account of Subscriptions:— | | | | | | |
| Arrears ... ... ... ... ... ... | 178 | 10 | 0 | | | |
| 257 Annual Contributions for 1890 ... ... | 539 | 14 | 0 | | | |
| 3 „ „ 1891 ... ... | 6 | 6 | 0 | | | |
| 30 Admission Fees ... ... ... ... | 63 | 0 | 0 | | | |
| 26 First Contributions ... ... ... ... | 40 | 19 | 0 | | | |
| | | | | 828 | 9 | 0 |
| 8 Composition Fees ... ... ... ... | | | | 168 | 0 | 0 |
| Sales of Publications:— | | | | | | |
| At Williams and Norgate's, 1889 ... ... | 22 | 19 | 0 | | | |
| At Society's Rooms, 1890 ... ... ... | 40 | 15 | 6 | | | |
| | | | | 63 | 14 | 6 |

Audited and found correct, 1891 Jan. 6.

ARTHUR COTTAM,
ROBT. J. LECKY,
W. H. MAW.

£2,457 9 9

*Astronomical Society, from January 1 to December 31, 1890.*

EXPENDITURE.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Assistant Secretary: Salary ... ... .. | 250 | 0 | 0 | | | |
| ,, ,, for assistance in editing Society's Publications ... | 50 | 0 | 0 | | | |
| | | | | 300 | 0 | 0 |
| Income Tax and House Duty ... ... .. | 10 | 10 | 0 | | | |
| Fire Insurance ... ... ... ... .. | 7 | 16 | 6 | | | |
| | | | | 18 | 6 | 6 |
| Printing, &c. ... ... ... ... ... .. | 407 | 14 | 10 | | | |
| Engraving, Lithography, &c. ... ... .. | 44 | 16 | 6 | | | |
| | | | | 452 | 11 | 4 |
| Computation of Ephemerides ... ... ... | 50 | 0 | 0 | | | |
| Correction of Lunar Computations ... ... ... | 3 | 3 | 0 | | | |
| | | | | 53 | | 0 |
| Turnor and Horrox Fund: purchases for Library | 8 | 12 | 8 | | | |
| Binding Books in Library ... ... ... ... | 48 | 7 | 4 | | | |
| | | | | 57 | 0 | 0 |
| Expenses of Eclipse Expeditions ... ... ... | | | | 65 | 7 | 3 |
| Alterations and Fittings in Upper Library and Basement ... ... ... ... ... | 249 | 12 | 0 | | | |
| Carpet and Chairs in Upper Library, and Range in Kitchen ... ... ... ... ... ... | 52 | 3 | 10 | | | |
| Sundry Fittings and Repairs ... ... ... | 6 | 4 | 4 | | | |
| | | | | 308 | 0 | 2 |
| Gold Medals ... ... ... ... ... ... | | | | 52 | 10 | 0 |
| Purchase of Lunar Globe ... ... ... ... | | | | 1 | 1 | 0 |
| House Expenses ... ... ... ... .. | 32 | 17 | 7 | | | |
| Wages ... ... ... ... ... .. | 31 | 14 | 0 | | | |
| Postage ... ... ... ... ... ... | 82 | 10 | 9 | | | |
| Carriage of Parcels ... ... ... ... ... | 1 | 12 | 2 | | | |
| Stationery and Office Expenses ... ... ... | 9 | 3 | 10 | | | |
| Brown Paper, &c., for repacking Stock ... ... | 6 | 14 | 6 | | | |
| Expenses of Meetings ... ... ... ... | 20 | 0 | 0 | | | |
| Coals and Gas ... ... ... ... ... | 53 | 8 | 2 | | | |
| Electric Lighting Expenses ... ... ... | 11 | 4 | 9 | | | |
| Time Signal: Rental of Wire ... ... ... | 5 | 0 | 0 | | | |
| Advertising ... ... ... ... ... ... | 4 | 11 | 6 | | | |
| Sundries ... ... ... ... ... ... | 3 | 9 | 6 | | | |
| | | | | 262 | 6 | 9 |
| Mrs. Jackson Gwilt's Annuity ... ... ... | 8 | 19 | 0 | | | |
| Lee and Janson Fund Grants ... ... ... | 12 | 10 | 0 | | | |
| | | | | 21 | 9 | 0 |
| Purchase of £500 Metropolitan 3 per cent. Stock at 102, including Commission ... ... ... | | | | 510 | 13 | 0 |
| Cheque-book ... ... ... ... ... ... | 0 | 8 | 4 | | | |
| Bankers' Deductions on Cheques ... ... ... | 0 | 3 | 6 | | | |
| | | | | 0 | 11 | 10 |
| Balances, December 31, 1890:— | | | | | | |
| at Bankers', as per Pass Book ... ... | 342 | 10 | 1 | | | |
| Cheque not Credited till 1891 ... ... | 2 | 2 | 0 | | | |
| in hand of Assistant Secretary on account of Turnor and Horrox Fund ... ... | 6 | 0 | 9 | | | |
| in hand of Assistant Secretary on Petty Cash Account ... ... ... ... | 3 | 17 | 1 | | | |
| | | | | 354 | 9 | 11 |
| | | | | £2,457 | 9 | 9 |

*Assets and Present Property of the Society, January* 1, 1891.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Balances, December 31, 1890:— | | | | | | |
| At Bankers', as per Pass Book ... ... ... | 342 | 10 | 1 | | | |
| Cheque not Credited till 1891 ... ... ... | 2 | 2 | 0 | | | |
| In hand of Assistant Secretary on account of Turnor and Horrox Fund ... ... | 6 | 0 | 9 | | | |
| In hand of Assistant Secretary on Petty Cash Account ... ... ... ... ... | 3 | 17 | 1 | | | |
| | | | | 354 | 9 | 11 |
| Due on account of Subscriptions:— | | | | | | |
| 1 Contribution of 5 years' standing ... ... | 10 | 10 | 0 | | | |
| 4 Contributions of 4 ,, ... ... | 33 | 12 | 0 | | | |
| 13 ,, 3 ,, ... ... | 81 | 18 | 0 | | | |
| 31 ,, 2 ,, ... ... | 130 | 4 | 0 | | | |
| 60 ,, 1 ,, ... ... | 126 | 0 | 0 | | | |
| 3 Admission Fees and 1st Subscriptions | 9 | 9 | 0 | | | |
| | 391 | 13 | 0 | | | |
| Less 3 Contributions paid in advance ... | 6 | 6 | 0 | | | |
| | | | | 385 | 7 | 0 |
| Due from Messrs. Williams and Norgate for sales of Publications during 1890 ... ... ... ... ... ... | | | | 25 | 3 | 0 |
| Due from Messrs. Wesley & Son, from sale of old non-astronomical books ... ... ... ... ... ... ... | | | | 18 | 18 | 1 |
| £7,500 $2\frac{3}{4}$ per Cent. Consols, including the Lee and Janson Fund, and the Turnor and Horrox Memorial Funds. | | | | | | |
| £5,700 $2\frac{3}{4}$ per Cent. Consols, including Mrs. Jackson Gwilt's gift (£300). | | | | | | |
| £1,250 Metropolitan 3 per Cent. Stock. | | | | | | |
| Astronomical and other Manuscripts, Books, Prints, Instruments, and Furniture. | | | | | | |
| Unsold Publications of the Society. | | | | | | |
| 5 Gold Medals | | | | | | |

*Report of the Auditors.*

We have examined the Treasurer's accounts for the year 1890, and have found and certified the same to be correct. The cash in hand on Dec. 31, 1890, including the balance at the bankers', amounted to 354*l.* 9*s.* 11*d.*

The funded property of the Society has been increased by the purchase of 500*l.* Metropolitan 3 per cent. stock.

The books, instruments, and other effects have been examined, and they appear to be in a satisfactory condition.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting, with the amount due against each Fellow's name.

Arthur Cottam,
Robt. J. Lecky,
W. H. Maw.

Stock in hand of volumes of the *Memoirs*:—

| Vol. | At Society's Rooms | At Williams & Norgate's | Vol. | At Society's Rooms | At Williams & Norgate's |
|---|---|---|---|---|---|
| I. Part 1 | 7 | ... | XXX. | 157 | 1 |
| I. Part 2 | 42 | ... | XXXI. | 140 | ... |
| II. Part 1 | 54 | ... | XXXII. | 152 | 1 |
| II. Part 2 | 20 | ... | XXXIII. | 161 | ... |
| III. Part 1 | 65 | 1 | XXXIV. | 162 | 4 |
| III. Part 2 | 84 | 1 | XXXV. | 107 | 5 |
| IV. Part 1 | 77 | 3 | XXXVI. | 195 | 8 |
| IV. Part 2 | 90 | 3 | XXXVII. Part 1 | 337 | 8 |
| V. | 102 | 3 | XXXVII. Part 2 | 283 | 8 |
| VI. | 123 | 3 | XXXVIII. | 268 | 1 |
| VII. | 146 | 3 | XXXIX. Part 1 | 242 | 4 |
| VIII. | 126 | 3 | XXXIX. Part 2 | 243 | 3 |
| IX. | 133 | 3 | XL. | 262 | ... |
| X. | 146 | ... | XLI. | 408 | 2 |
| XI. | 152 | ... | XLII. | 232 | 3 |
| XII. | 159 | ... | XLIII. | 235 | 2 |
| XIII. | 163 | ... | XLIV. | 217 | ... |
| XIV. | 366 | 2 | XLV. | 247 | ... |
| XV. | 139 | ... | XLVI. | 231 | 1 |
| XVI. | 163 | ... | XLVII. Part 1 | 3 | ... |
| XVII. | 146 | 1 | XLVII. Part 2 | 18 | ... |
| XVIII. | 140 | ... | XLVII. Part 3 | 2 | ... |
| XIX. | 147 | ... | XLVII. Part 4 | 10 | ... |
| XX. | 141 | ... | XLVII. Part 5 | 10 | ... |
| XXI. Part 1 | 312 | ... | XLVII. Part 6 | 10 | ... |
| XXI. Part 2 | 98 | ... | XLVII. | 214 | 1 |
| XXI. 1 & 2 (together) | 61 | ... | XLVIII. Part 1 | 253 | 3 |
| XXII. | 163 | ... | XLVIII. Part 2 | 263 | 2 |
| XXIII. | 147 | ... | XLIX. Part 1 | 485 | 2 |
| XXIV. | 155 | ... | XLIX. Part 2 | 247 | 4 |
| XXV. | 165 | ... | Index to *Memoirs* | 644 | ... |
| XXVI. | 171 | ... | | | |
| XXVII. | 423 | ... | | | |
| XXVIII. | 381 | ... | | | |
| XXIX. | 403 | 1 | | | |

Stock in hand of volumes of the *Monthly Notices* :—

| Vol. | At Society's Rooms | At Williams & Norgate's | Vol. | At Society's Rooms | At Williams & Norgate's |
|---|---|---|---|---|---|
| I. | 64 | ... | XXVII. | 4 | ... |
| II. | 65 | ... | XXVIII. | 72 | ... |
| III. | ... | ... | XXIX. | 52 | ... |
| IV. | ... | ... | XXX. | 65 | 2 |
| V. | ... | ... | XXXI. | 94 | ... |
| VI. | 50 | ... | XXXII. | 116 | 5 |
| VII. | 2 | ... | XXXIII. | 98 | 1 |
| VIII. | 153 | 2 | XXXIV. | 75 | 1 |
| IX. | 24 | 3 | XXXV. | 58 | ... |
| X. | 179 | 1 | XXXVI. | 31 | 1 |
| XI. | 184 | 1 | XXXVII. | 38 | 3 |
| XII. | 106 | 2 | XXXVIII. | 101 | 2 |
| XIII. | 178 | 3 | XXXIX. | 98 | 1 |
| XIV. | 177 | 3 | XL. | 112 | 3 |
| XV. | 169 | 2 | XLI. | 112 | 5 |
| XVI. | 154 | 2 | XLII. | 121 | 1 |
| XVII. | 167 | 1 | XLIII. | 121 | ... |
| XVIII. | 245 | ... | XLIV. | 124 | 3 |
| XIX. | 57 | ... | XLV. | 123 | 2 |
| XX. | 34 | ... | XLVI. | 118 | 2 |
| XXI. | 17 | ... | XLVII. | 136 | 4 |
| XXII. | 33 | ... | XLVIII. | 128 | 4 |
| XXIII. | 19 | ... | XLIX. | 123 | 13 |
| XXIV. | 24 | ... | L. | 125 | 16 |
| XXV. | 15 | ... | Index ... | 565 | 3 |
| XXVI. | 11 | ... | | | |

LIBRARY CATALOGUE ... ... ... ... ... ... 579

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly all the volumes. With the exception, however, of Vols. XXXVI. to L. no complete volumes can be formed from the separate numbers in stock.

*Instruments belonging to the Society.*

No. 1. The *Harrison* clock.
„ 2. The *Owen* portable circles, by Jones.
„ 3. The *Beaufoy* circle.

No. 4. The *Beaufoy* transit instrument.
„ 5. The *Herschel* 7-foot telescope.
„ 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Utzschneider and Fraunhofer, of Munich.
„ 7. The *Smeaton* equatoreal.
„ 8. The *Cavendish* apparatus.
„ 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
„ 10. The variation transit instrument (late Mr. Shearman's).
„ 11. The universal quadrat, by Abraham Sharp.
„ 12. The *Fuller* theodolite.
„ 13. The standard scale, by Troughton and Simms.
„ 14. The *Beaufoy* clock, No. 1.
„ 15. The *Beaufoy* clock, No. 2.
„ 16. The *Wollaston* telescope.
„ 17. The *Lee* circle.
„ 18. The *Sharpe* reflecting circle.
„ 19. The *Brisbane* circle.
„ 20. The *Baker* universal equatoreal.
„ 21. The *Reade* transit.
„ 22. The *Matthew* equatoreal, by Cooke.
„ 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A sextant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.
The *Sheepshanks* collection :—
„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.
„ 29. (3) Equatoreal stand and clock movement for $4\frac{6}{10}$-inch telescope (telescope lost); double-image micrometer; two wire micrometers; object-glass micrometer.
„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatoreal stand; double-image micrometer; one terrestrial and three astronomical eyepieces.
„ 31. (5) $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.
„ 33. (7) 2-foot navy telescope.
„ 34. (8) Transit instrument of 45 inches focal length, with iron stand and also Ys for fixing to stone piers; two axis levels.
„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.

No. 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.

„ 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, read to 10″ by two verniers to each circle.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end, reading to single minutes; horizontal circle 9 inches diameter in brass, reading to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{5}{8}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator, with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon, with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

„ 46. (20) Reflecting circle, by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.

„ 47. (21) Box sextant; reflecting plane and level.

„ 48. (22) Prismatic compass, by Troughton and Simms.

„ 49. (23) Mountain barometer.

„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.

No. 51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.
„ 52. (26) Dipping needle, by Robinson.
„ 53. (27) Compass needle, mounted for variation.
„ 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen; a strongly fitted brass box with heavy magnet; filar suspension.
„ 55. (29) Box of magnetic apparatus.
„ 56. (30) Hassler's reflecting circle, by Troughton; a $10\frac{1}{2}$-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices; four verniers reading to 10″.
„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.
„ 58. (32) Plane $2\frac{3}{8}$-inch speculum, artificial horizon, and stand.
„ 59. (33) $2\frac{1}{2}$-inch circular level horizon, by Dollond.
„ 60. (34) Artificial horizon, roof, and trough; the trough $8\frac{1}{4}$ by $4\frac{1}{2}$ inches; tripod stand.
„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square; one beam compass.
„ 62. (36) A pantograph.
„ 63. (37) A noddy.
„ 64. (38) A small Galilean telescope with object-glass of rock crystal.
„ 65. (39) Five levels.
„ 66. (40) 18-inch celestial globe.
„ 67. (41) Varley stand for telescope.
„ 69. (43) Telescope, with object-glass of rock crystal.
„ 71. Portable altazimuth tripod.
„ 72. Four polarimeters.
„ 74. Registering spectroscope, with one large prism.
„ 76. Two five-prism direct-vision spectroscopes.
„ 78. $9\frac{1}{4}$-inch silvered-glass reflector and stand, by Browning.
„ 79. Spectroscope.
„ 80. A small box, containing three square-headed Nicol's prisms; two Babinet's compensators; two double-image prisms; three Savarts; one positive eyepiece, with Nicol's prism; one dark wedge.
„ 81. A back-staff, or Davis' quadrant.
„ 82. A nocturnal or star dial.
„ 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.
„ 84. A Hollis observing chair.
„ 85. Double image micrometer, by Troughton and Simms.
„ 86. $4\frac{1}{2}$-inch Gregorian reflecting telescope, by Short,

with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.

No. 87. $3\frac{1}{4}$-inch Gregorian reflecting telescope with wooden tripod stand.

„ 88. Pendulum, with 5-foot brass suspension rod, working on knife edges, by Thomas Jones.

„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.

„ 90. An Arabic celestial globe of bronze, $5\frac{3}{4}$ inches in diameter.

„ 91. Astronomical time watchcase, by Professor Chevallier.

„ 92. 2-foot protractor, with two movable arms, and vernier.

„ 93. Beam compass, in box.

„ 94. 2-foot navigation scale.

„ 95. Stand for testing measures of length.

„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position-angles.

„ 97. 12-cell Leclanché battery.

„ 98. 2 feet 6 inch navy telescope, with object-glass $2\frac{1}{2}$ inches, by Cooke, with portable wooden tripod stand.

„ 99. 12-inch transit instrument, by Fayrer and Son, with level and portable stand.

„ 100. 9-inch transit instrument, with level and iron stand.

„ 101. Small equatoreal sight instrument, by G. Adams, London.

„ 102. Sun-dial, by Troughton.

„ 103. Sun-dial, by Casella.

„ 104. Sun-dial.

„ 105. Box sextant, by Troughton and Simms.

„ 106. Prismatic compass, by Schmalcalder, London.

„ 107. Compass, by C. Earle, Melbourne.

„ 108. Prismatic compass, by Negretti and Zambra.

„ 109. Dipleidoscope, by E. Dent.

„ 110. Abney level, by Elliott.

„ 111. Pocket spectroscope, by Browning.

„ 112. Universal sun-dial.

„ 113. Double sextant, by Jones.

„ 114. Two models, illustrating the effects of circular motions.

„ 115. A cometarium.

No. 116. A pair of 18-inch globes.
„ 117, 118 } Two old sun-dials.
„ 119. Specimens of diffraction gratings, by Prof. W. A. Rogers.
„ 120. A 6-prism spectroscope, by Browning.
„ 121. Spitta's improved maximum and minimum thermometer.
„ 122. A 6-inch speculum, with flat; the speculum said to be by Sir W. Herschel, and re-figured by Sir J. Herschel.
„ 123. A 6-inch refracting telescope, by Grubb, with 3 eyepieces.
„ 124. Position micrometer, by Cooke.
„ 125. A 6-inch refracting telescope, by Simms, with eyepieces and solar diagonal.
„ 126. $3\frac{1}{2}$-in. portable refracting telescope, by Tulley, with tripod stand.
„ 127. Globe representing the visible surface of the Moon, by John Russell, R.A. (1797).
„ 128. Bichromate battery and Ruhmkorff coil (presented by Mr. J. E. H. Peyton).

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons :—

No. 4. The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.
„ 10. Variation transit, to Mr. Maxwell Hall.
„ 16. The *Wollaston* telescope, to Mr. R. Inwards.
„ 22. The *Matthew* equatoreal, to Mr. J. Brett.
„ 23. The *Matthew* transit, to Captain W. Noble.
„ 27. (1) 30-in. transit and one stand, to Mr. C. Thwaites.
„ 28. (2) 6-inch theodolite and stand, to Mr. A. A. Common.
„ 29. (3) Equatoreal mounting, clock movement, and pillar, to Mr. W. Peck.
„ „ Wire micrometer (No. 1), to Mr. C. Thwaites.
„ „ Wire micrometer (No. 2), to Mr. Maxwell Hall.
„ 30. (4) $3\frac{1}{4}$-inch equatoreal and stand, to Mr. E. B. Powell.
„ „ „ Double image micrometer, to Mr. Maxwell Hall.
„ 34. (8) Transit instrument and stand, to Professor C. Pritchard.
„ 38. (12) 18-inch *Borda* repeating circle, to Mr. Maxwell Hall.
„ 39. (13) 8-inch repeating circle, to Mr. J. Norman Lockyer.
„ 42. (16) Artificial horizon, roof, and mercury bottle, to Mr. C. Thwaites.
„ 50. (24) Prismatic compass, to Mr. Maxwell Hall.

No. 52. (26) Dipping needle, to Mr. Maxwell Hall.
„ 54. (28) Magnetic intensity needle, to Mr. Maxwell Hall.
„ 69. (43) Telescope, with rock-crystal object-glass, to Dr. W. Huggins.
„ 78. $9\frac{1}{4}$-inch reflector and stand, to Mr. Maxwell Hall.
„ 79. Spectroscope, to Mr. Maxwell Hall.
„ 86. $4\frac{1}{2}$-inch Gregorian reflector by Short (two mirrors only), to Mr. A. A. Common.
„ 125. 6-in. refractor by Simms, to the Rev. A. Freeman.

*The Gold Medal.*

No Gold Medal has been awarded by the Council this year.

## Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year:—

Fellows:—Wentworth Erck.
General Edward Frome.
W. J. Ibbetson.
Harry Taylor.
Rev. Alfred Weld.

Associates:—C. H. F. Peters.
O. A. Rosenberger.
Herman Schultz.

Wentworth Erck was born in Dublin in 1827, and was the eldest son of John Caillard Erck, of Huguenot descent, an Ecclesiastical Commissioner for Ireland. His prænomen he derived by right of his grandmother, Elizabeth Wentworth, niece of Sir John Wentworth, baronet, Lieut.-Governor of Nova Scotia in 1808. Educated in part at Rugby, he graduated at Trinity College, Dublin, in 1850, and was in the same year called to the Irish Bar. In 1859 he took the degree of LL.D. Chemistry and mechanics had been the pastimes of his boyhood, and while still a youth he developed the predilection for astronomy which distinguished him through life. On his marriage, the better to discharge his duties to his tenantry he chose for his residence "Sherrington," not far from his landed property in the county Wicklow. He there erected an observatory, of which, and of his investigations, the following account has been kindly supplied by Mr. Arthur A. Rambaut, Assistant-Astronomer at Dunsink:—

"Dr. Erck's observatory, as well as a great many details in the construction of his instruments, was designed by himself to suit his special requirements. The object-glass of his equatoreal was a $7\frac{1}{2}$-inch, by Alvan Clark, which had formerly belonged to the late Mr. Dawes, and with which much of the earlier work of that distinguished observer had been accomplished. It is in

some respects a remarkable glass, being so full of bubbles that to one versed in such matters it might have appeared almost worthless for the delicate purpose for which it was intended; whereas it is remarkable for the exquisite definition it is capable of affording, as was proved on more than one occasion by the work done with it in the hands of Mr. Dawes and Dr. Erck.

"Within the last few years he obtained an important addition to his instrumental equipment in a fine silver-on-glass reflector of 15 inches aperture, for which he designed an alt-azimuth mounting, completed a little before his death.

"From the commencement of his career as an observer he paid especial attention to the appearance of the Sun's disc, and has left a record of the appearance of its surface on a large number of days in each year from 1869 up till 1888. In the earlier years of this period he contented himself with a general description of the appearance and position of the spots and faculæ from day to day, with occasionally a pen-and-ink sketch of the more remarkable forms. About the middle of this period, however, he had a reticule of glass, with small squares ruled on it, inserted in the focus of his telescope, with which he was enabled to determine the positions of the markings with sufficient accuracy for the purpose of identification.

"He spent a portion of nearly every year in London, and in order to continue unbroken his series of solar observations, he was in the habit of taking with him a small telescope of $3\frac{1}{2}$ inches aperture, with which he was enabled, by means of a portable equatoreal mounting, described by him in the pages of the *Monthly Notices*, to carry on his solar work.

"But although his observations of the Sun occupied a large part of his attention, they by no means exhausted it. He took a keen interest in almost all branches of observational astronomy. His most sustained labours, next to the series of his solar observations, were devoted to some double stars which were known or suspected to constitute binary systems. In this connection he devoted himself entirely to measuring position angles, leaving the determination of distance to those possessing telescopes of larger aperture. His attention was principally directed to some forty selected binaries, of which he obtained more than 1,900 measurements between the years 1873 and 1880, during which period he seems to have been most active as an observer.

"From time to time, as they appeared, Dr. Erck observed and recorded the appearance of the brighter comets, and was in the habit of sending occasional notices of such events to the local papers, as well as to the scientific periodicals.

"He paid a good deal of attention to the faint comites of some of the brighter stars, such as *Sirius*, *Procyon*, and *Rigel*; and at the opposition of *Mars* in 1877 he distinguished himself as one of the very few observers in this country who were able to pick up the satellites of that planet, which had been lately discovered by Professor Asaph Hall with the great 26-inch

achromatic at Washington—a remarkable feat for so small a telescope, and one requiring a keen-sighted observer at the eye-end.

"Among other phenomena which engaged the attention of Dr. Erck was the appearance of *Jupiter's* surface in the year 1880, at which time the red spot was very conspicuous. He appears to have been one of the first, if not the very first, to notice the proper motion of this spot with regard to the general surface of the planet. The appearance of *Saturn's* rings and the comparative brightness of his satellites also engaged a good deal of his attention from time to time, although he does not appear to have published the results of these observations. Indeed, his published works bear a very small proportion to the extent of his labours, and, to judge exclusively by this standard, one would form a most inadequate estimate of his astronomical activity. Those who have known him, however, will not lightly forget his zeal and enthusiasm, and the interest he took in all questions touching his favourite science, or the hearty manner and ready hospitality which made a visit to the Sherrington Observatory so memorable and agreeable."

Dr. Wentworth Erck contributed several papers to the *Monthly Notices* on observational astronomy and instrumental appliances.

Dr. Erck's devotion to science was not allowed to interfere with the discharge of his duties as a Poor-Law guardian, a magistrate, and a country gentleman. He was at one time invited to stand for Parliament in the Conservative interest, but declined. That the energy he displayed in his public duties used up his capital of health and shortened his life there can be little doubt; but his appetite for work was keen and his spirit indomitable, and he always expressed the desire, which was granted him, to "die in harness." His unfailing good temper, his child-like heart, his simplicity of character, and his perfect contentment attracted to him a wide feeling of respect.

His death took place at his residence on January 15 of the past year.

He was elected a Fellow of this Society March 9, 1855.

Edward Charles Frome was born at Gibraltar on January 7, 1802. He was the son of the Rev. J. T. Frome, a member of a well-known Dorsetshire family. He was educated first at a school at Bexley, afterwards at a school at Blackheath, where he was a schoolfellow of Benjamin Disraeli. In his fifteenth year he entered the Royal Military Academy at Woolwich, where he studied engineering under Olinthus Gregory and Peter Barlow, and attended the science lectures of Faraday. He distinguished himself in all his examinations, and passed out for his commission at the head of his batch. There were at that time no vacancies in the Royal Engineers, and it was not

till the year 1825 that he was gazetted second lieutenant in this branch of the service.

Early in his career, in 1827, he was ordered to Canada, where he made the whole of the surveys for the Rideau Canal, connecting the Ottawa River with Kingston on Lake Ontario. The construction of the main part of this important work he superintended until its completion.

In 1835 he succeeded Lieutenant, afterwards Sir William Denison, at Chatham as Instructor in Surveying and Practical Astronomy. At this time he published his work entitled "An Outline of the Method of Conducting a Trigonometrical Survey."

In 1839 Lieutenant Frome was offered the post of Surveyor-General of the Colony of South Australia. He accepted the appointment on condition that he should have the sole control of the work. At this time the work of the survey was lamentably in arrear, and the greatest confusion existed as to the boundaries of land. Captain Frome, who had been promoted soon after his arrival in the colony, undertook, as his first work, a thorough system of triangulation, afterwards employing a staff of some 400 men, in independent surveying parties of 10 men each, to fill in the details. The result of this organisation was, that in a comparatively short time the work of the survey was brought well in advance of the requirements of the Land Commissioners, and the cost greatly reduced.

It was for the use of these independent surveying parties that Captain Frome published his pamphlet of "Instructions for the Interior Survey of South Australia," which was afterwards incorporated in the later edition of his work on "Trigonometrical Surveying." This has long been a standard work, and a fourth edition of it, greatly enlarged, and edited by Sir Charles Warren, has recently appeared. For ten years Captain Frome was engaged in surveys which embraced all the then known parts of South Australia, and in addition a considerable portion which he was the first to explore. He returned to England in 1849. In 1851 he was appointed Surveyor-General of Mauritius—an appointment which he held until 1858, when he returned home. In 1863 Colonel Frome went out as Commanding Royal Engineer to Gibraltar, and in 1868 he succeeded Sir John Burgoyne as Inspector-General of Fortifications and Inspector of the corps of Royal Engineers. Subsequently he was appointed Lieutenant-Governor of Guernsey, which post he held for five years.

General Frome throughout his long life took the keenest interest in everything connected with engineering. Whatever he undertook he did thoroughly and well. He was a man of a high tone of mind, the first principle which guided his life being the call of duty. He was modest and unassuming in character and was honoured and respected by all who knew or had served under him. When he died on February 12, 1890, he was at the head of his corps, of which he was the senior Colonel Commandant.

General Frome was an Associate of the Institution of Civil Engineers for fifty-two years. He was elected a Fellow of this Society May 11, 1838.

Harry Taylor was born at Bocking, in the County of Essex, on May 29, 1831. He was a descendant of an old Huntingdonshire family which formerly bore the name of Taylard. Mr. Taylor received his education at Mr. Malleson's school at Hove, and at University College, London. He took much interest in astronomy, but did not devote himself to any special research. As a business man he was extremely shrewd and clever, and possessed faculties that were of high value to the firm of which he was a member. He died April 27, 1890, after a short illness.

He was elected a Fellow of this Society November 10, 1871.

Alfred Weld was born on August 5, 1823. He was the son of Mr. George Weld, of Seagrave, and grandson of Mr. Thomas Weld, of Lulworth—a well-known county family. He was educated at Stonyhurst, where he took a prominent place. In 1842 he entered the Society of Jesus, and in 1847 graduated at the London University. In 1848 he took charge of the meteorological observatory at Stonyhurst, in which position he continued for three years.

During this period, in 1848, the late Father Secchi, who was then a theological student, came to Stonyhurst in consequence of the expulsion of the Jesuits from Rome. Father Weld showed him round the Observatory, and interested him so much in the work that there are some grounds for believing Secchi was thereby induced to devote himself to astronomy. There is a tradition at Stonyhurst that Secchi's first astronomical observations were made with the 4-inch equatoreal of that Observatory.

In 1851 Father Weld retired from scientific work in order to devote himself to theological studies. He was ordained in 1854, and resumed charge of the Observatory in 1857.

In the magnetic survey of Great Britain, undertaken by Sir Edward Sabine in 1858, Father Weld was much interested; and having purchased a set of instruments, he inaugurated that series of magnetic observations which has been carried on uninterruptedly at Stonyhurst Observatory to the present time. At this period also he organised the astronomical work of the College.

In 1860 Father Weld resigned charge of the Observatory, and was succeeded by the late Father Perry.

In 1864 he was made Provincial of the English Province of the Society of Jesus, and in that position did much to aid and encourage the work at the Stonyhurst Observatory. In 1871 he was appointed Rector of the theological college of St. Beuno. In 1873 he became assistant to the Father-General of the Society

of Jesus, and finally, in 1884, he was made Superior of the Mission on the Zambesi. He died at St. Aidan's College, Grahamstown, on July 24 of the past year.

Father Weld was a man of exceedingly polished manners, and distinguished by great energy and tact in the conduct of business. He was twice employed by His Holiness Pope Leo XIII. in the management of delicate affairs, in which he succeeded admirably. How bravely he bore himself at Gibraltar under the savage attack of a mob of roughs is well known. He never lost his interest in science. When Provincial he gave Father Perry all possible encouragement. When Superior of the Zambesi Mission he set up a Stevenson screen and meteorological instruments at St. Aidan's College. Moreover, he purchased a set of instruments for observing the magnetic elements, and sent an assistant to M. d'Abbadie to be trained in their use, so that he might make magnetic observations in his missionary journeys. Unfortunately, the instruments becoming damaged, without means of getting them repaired, the attempt was rendered abortive.

Father Weld published a few communications in Vol. XI. of the *Monthly Notices*. He contributed several articles on scientific subjects to the *Month*, and he was the author of an extensive historical work on the suppression of the Jesuits in Portugal.

He was elected a Fellow of this Society January 12, 1849.

Christian Heinrich Friedrich Peters was born on September 19, 1813, at Coldenbüttel, in the province of Schleswig, where his father, Hartwig Peters, was a minister. He received his early education, from 1825 to 1832, at the Gymnasium at Flensburg, and subsequently proceeded to Berlin, where he studied mathematics and astronomy under Encke. After taking his Doctor's degree in 1836 he tried to obtain an appointment at the Copenhagen Observatory, in which he was unsuccessful. He then went to Göttingen to pursue his studies under Gauss. He subsequently accompanied Sartorius von Waltershausen to Mount Etna to make a scientific survey of the mountain, and afterwards was made director of the Trigonometrical Survey of Sicily, which position he occupied for some years.

On the revolution breaking out in 1848 he took part against the Government, and was deprived of his appointment. He had to escape on board an English vessel to Malta, whence he soon returned to Sicily, where he took service in the Sicilian army as Captain of Engineers, under Mieroslawski. He soon became major, and under his direction Catania and Messina were fortified. When Palermo fell into the hands of the Neapolitans in May 1849, Peters fled to France, but shortly afterwards proceeded to Constantinople.

Here he made many friends, and the Sultan proposed to send him in charge of a scientific expedition to Syria and Palestine.

Various obstacles stood in the way, and on the Crimean war breaking out in 1854 the expedition was abandoned. This time, however, was valuable to Peters, as it enabled him to become proficient in the Turkish and Arabic languages, which proved of essential service to him of late years in his researches on Ptolemy's Catalogue of Stars.

In 1854 he went to the United States with recommendations from Alexander von Humboldt to the Observatory at Cambridge, Massachusetts. Thence he went to Washington, where he obtained an appointment on the United States Coast Survey. He then became connected with an observatory at Utica, and finally in 1858 was appointed director of the Litchfield Observatory at Clinton, New York, and Professor of Astronomy at Hamilton College, which appointments he held until the day of his death.

Dr. Peters published his first scientific paper in the 13th volume of the *Astronomische Nachrichten*, on the Solar Eclipse of 1836 May 15; and during his life he contributed several papers to the same journal.

About 1845 Peters began his important researches on the Sun, which he continued till some time after 1865. The observations of Sun-spots which he made at Naples in 1845–1846 with a $3\frac{1}{2}$-inch refractor have never been entirely published; but an admirable paper, based upon those observations and entitled "Contributions to the Atmospherology of the Sun," was published by him in 1855 in vol. ix. of the Proceedings of the American Association for the Advancement of Science. In this paper, which has been characterised as much in advance of anything else which has appeared on the subject, he describes the growth and decay of Sun-spots, and records the remarkable phenomena of flashes extending across an umbra with electrical velocity, in these words: "Two of the notches in the margin of a Sun-spot, from opposite sides, step forward into the area, overroofing even a part of the nucleus; and suddenly from their prominent points flashes go out, meeting each other on their way, hanging together for a moment, then breaking off and receding to their points of starting. Soon this electric play begins anew, and continues for a few minutes, ending finally with the connection of the two notches, thus establishing a bridge, and dividing the spot into two parts. The flashes proceed with great speed, but not so that the eye may not follow them distinctly." On the subject of the *proper motion* of Sun-spots, Peters will rank among the earliest observers who clearly recognised this feature. His remarks thereon in the above-mentioned paper may fitly be quoted. He says: "The first fact now, which offers itself, in comparing the heliographic places of one and the same spot for different days, is that the spots are not invariably attached to the Sun's surface, but have *proper motion*. A general proper motion of the spots towards the Equator being recognised, the question is raised naturally: Have they any motion also in longitude? and in what direction—to the east or to the west? The solution of this question is intimately connected with the

determination of the time of rotation. For it is clear, if all the spots had an equal proper motion in longitude, the time of the Sun's rotation, since it is deduced from the spots, would be wrong. In other words, it is the time of rotation of the spots which results, and not that of the Sun itself . . . there can be no doubt of a very considerable motion parallel to the Equator. The displacements in longitude seem even far more considerable than those in latitude. Whether there be a common motion, and in what direction, cannot be decided in the present state of our knowledge of the Sun's rotation."

Carrington thus remarks on the above discovery : " So nearly did this able observer come to the term in latitude without obtaining it, and leave its actual determination to me."

In 1860 he determined to devote the 13-inch refractor of the Litchfield Observatory to the preparation of a series of zodiacal star-charts, to include all stars visible with a power of 80 upon that telescope. His desire was to represent portions of the sky in a picture that in future ages might serve as a sure basis for drawing conclusions as to changes going on in the starry heavens. This was before photography presented itself as a more satisfactory method of realising that aspiration. The first instalment of Peters' zodiacal charts was published in 1882, and at present twenty only are in the hands of astronomers, but many more are nearly or quite completed. The zone observations which form the groundwork of these charts number over 100,000.

The zeal and assiduity with which Peters pursued this work met with their reward in the discovery of the remarkable number of 48 minor planets.

In 1874 Peters acted as chief of the United States expedition to New Zealand to observe the transit of *Venus*. His station was at Queenstown, where he arrived on October 16, and remained exactly three months. His observations were seriously interfered with by bad weather, but he succeeded in securing a good observation of first internal contact.

Some few years ago Peters determined to collate, as far as possible, all existing manuscripts of the catalogue of stars which is be found in the 7th and 8th books of Ptolemy's *Almagest*, so as to produce a more accurate edition of that catalogue than we at present possess. For this purpose he visited the celebrated public libraries at Florence, Venice, Vienna, Paris, Berlin, and other cities on the continent, and collated all the available MSS. of the *Almagest* therein to be found. The collating of the MSS. in this country was undertaken by the writer of this notice, who had independently been working for the same object. In this work Peters showed high intelligence and sagacity in the interpretation of doubtful readings ; and the publication of the work may be looked forward to as likely to reveal many interesting points connected with the earliest known catalogue of the positions of stars.

On the morning of July 19, 1890, Dr. Peters was found lying dead upon the doorstep of the college building where he

lodged. His observing cap was on his head, and it is presumed that a sudden spasm from heart disease struck him down while on his way to the observatory to commence his nightly work.

Dr. Peters was a man of the highest integrity and honour, courteous in his bearing and of a most kindly nature. He was an accomplished scholar, and had great linguistic attainments, even to the extent of publishing a scientific paper in the Turkish language. He was an able and accurate mathematician and astronomer, whose fame is due "not to transcendent genius, or brilliant episodes, but to faithful, diligent toil, and life-long devotion to his chosen profession."

He was elected an Associate of this Society January 10, 1879.

Otto August Rosenberger, who at the time of his death was the senior Associate of this Society, was born on August 10, 1800, at Tukkum, in the province of Courland, in Russia. He was the son of a medical man, who, in 1811, migrated to Königsberg, in Prussia, probably in consequence of his brother being the director of the Gymnasium in that city, from whom young Rosenberger then received his early education. He entered the University of Königsberg as a student of mathematics in 1819, and pursued his academical studies till the autumn of 1825.

At this period the immortal Bessel was Director of the Königsberg Observatory. He readily recognised the talent displayed by the foreign student, who was one of his pupils at the University, and in 1823 he appointed him an assistant at the Observatory. In this position he remained for three years. During this period Rosenberger published his first scientific paper, which will be found in the first volume of the *Astronomische Nachrichten*, on the elements of the orbit of the comet of 1821; his second paper, on the elements of the comet of 1818, was published in Bode's *Jahrbuch* for 1824.

In 1826, a vacancy having occurred at the Observatory of Halle, Bessel proposed his assistant for the post, upon which Rosenberger was appointed Extraordinary Professor of Applied Mathematics at the Halle University, and Observer at the Observatory. In quitting Königsberg, Bessel recorded his good services to astronomy by saying: "The journals of the Observatory for the last few years contain proofs of his activity in the functions of this institution, which by his departure has lost an excellent assistant."

Rosenberger entered upon his duties at Halle in October 1826, having in the previous July taken his Doctor's degree at Königsberg. Five years later he was promoted to be Ordinary Professor of the University, and Director of the Observatory. In Halle his activity as an astronomer was seriously hampered by the condition of the Observatory, which had been built in 1790 merely for educational purposes. There were none but antiquated instruments, and not even a reliable clock. Consequently the first task he proposed to himself was to procure a

small meridian circle, a Fraunhofer telescope, of 6 feet focal length, and two clocks. Four years seem to have elapsed before these instruments were obtained and the necessary structural alterations made. But even then no systematic observations appear to have been made, and, indeed, it would seem that observational astronomy was somewhat distasteful to Rosenberger. During the long period of sixty-four years that he held the position of Professor in the University of Halle, he trained numerous pupils in mathematics, but, strange to say, none in astronomy. One of his pupils records from his own personal recollection that Rosenberger could scarcely ever be induced to bring the existing instruments into requisition for the purpose of astronomical instruction. The plea of the instruments being out of date, and the walls of the Observatory damp, hardly affords sufficient explanation of this anomaly in the life of one who to mathematical astronomy was able to contribute work of conspicuous and enduring merit.

In the history of astronomy Rosenberger is known solely by the remarkable investigation of the orbit of Halley's Comet, which he undertook in anticipation of its predicted appearance in 1835. The history of this comet is so well known that it may be considered superfluous to refer in detail to the interest excited in its reappearance in that year. Four mathematicians entered the field to calculate its orbit and determine the time of its perihelion passage—two Frenchmen, Damoiseau and Pontécoulant, and two Germans, Lehmann and Rosenberger. The methods adopted by these four distinguished astronomers in their investigations are well and succinctly explained in the address of Mr. (now Sir George) Airy, in the year 1837, on the occasion of presenting the gold medal of this Society to Professor Rosenberger.* The whole research of Rosenberger on Halley's Comet is contained in a series of papers published in the *Astronomische Nachrichten.*

In the first paper (*Ast. Nach.* No. 180) he gives a calculation of the elements of the orbit at the appearance in 1759, from all available observations made in that year. In No. 196 of the same journal, he investigates the elements at the appearance of 1682, from the observations of Flamsteed, Hevelius, De la Hire, and Picard. These two papers were described by Mr. Airy as "undoubtedly among the most complete papers of the kind that have ever appeared."

In No. 250, Rosenberger investigates the perturbations of the comet from 1682 to 1759. In this paper the effects of all the planets are estimated in the following manner:—"To 30° of eccentric anomaly the perturbations are computed, referring the comet's place to the Sun; from 30° to 60° the perturbations of *Mercury*, *Venus*, the Earth, and *Mars* are computed, referring the comet's place to the centre of gravity of the solar system;

* *Monthly Notices*, vol. iv. p. 57.

and from 60° to 300° those of *Jupiter*, *Saturn*, and *Uranus* are conducted in the same manner. From 300° to 330°, and then to 360°, the steps of the operation in the first part of the orbit are retraced."

In No. 276, he computes the perturbations from 1759 to 1835, and points out that the perturbations after 300° of eccentric anomaly are so excessively great that a very accurate knowledge of the comet's orbit is necessary to calculate them properly. In a further paper, No. 288, he indicates the importance of frequently changing the elements in the computation of the perturbations. "In some instances, in the first revolution, the elements were altered for every 2° of eccentric anomaly. The effect of these hitherto neglected cautions in computing the perturbations through only 16° of eccentric anomaly is an alteration of four days in the periodic time."

Bessel, in lecturing the following year upon the researches which had been made upon this comet, says: "Rosenberger's calculations have been the most successful ones. Certainly Pontécoulant, by a supplementary calculation published at a subsequent date, though still before the reappearance of the comet, has hit upon the time of perihelion passage more closely than Rosenberger, but a comparison of the other items of the prediction results in Rosenberger's favour. The values ascertained by Rosenberger are so approximately correct that they coincide with the whole series of observations which have now been made, but for some trifling discrepancies, which would have escaped detection had not the observations possessed such high accuracy."

As is well known, the comet was discovered on August 5, 1835, in a position within one degree of the place assigned to it for that day in Rosenberger's Ephemeris, and it arrived at perihelion on November 16, only four days after the time predicted by him.

The high merit of this elaborate investigation is well expressed in the concluding paragraph of Mr. Airy's address already referred to, and which may be here quoted:—"Professor Rosenberger has used the theory of perturbations in its most accurate form, and in one of its most delicate parts he has introduced an important correction. He has computed the perturbations of all the elements for the first as well as the second revolution; Damoiseau and Pontécoulant having only computed the change of mean motion and epoch for the first revolution. He has included in his calculations the effect of several planets which had been totally omitted by other mathematicians. He has not only computed the perturbations, but has also, from the observations of different astronomers at the former appearances, investigated the elements at those times by a process of the most accurate kind. So complete are the whole of these computations, that if names were taken, not from the discoverers of these bodies, or from those who conjecture their identity, but from those who, by

accurate calculations on a uniform system, combine the whole of our information relating to them, we should call this body, not Halley's, but Rosenberger's comet."

It must always be a subject of great regret that with this successful effort Rosenberger should have terminated his labours in astronomy. It does not appear that he published any further scientific work from 1836 to the day of his death.

He gave lectures on mathematics and astronomy regularly, though as a rule but to a small circle of students. Apart from his educational activity, he rendered valuable services to the university and faculty by the readiness with which he undertook manifold administrative functions, as well as by the conscientiousness, precision, and ability with which he performed them. He repeatedly and creditably filled the office of Dean of the Philosophical Faculty. For some period of his life at Halle he took a prominent part in politics, but of late years he seldom appeared in public except to attend some academical function.

On May 13, 1886, he celebrated the rare event of the sixtieth anniversary of his appointment as a professor, on which occasion the Emperor bestowed on him the second class order of the Red Eagle. Professor Rosenberger never married. At the time of his death in 1890, January 23, at the age of nearly ninety years, he was the senior Professor of the University of Halle and of the Philosophical Faculty.

He was elected an Associate of this Society April 10, 1835.

Herman Schultz was born on July 7, 1823, at Nygvarn, in the Swedish province of Södermanland, where his father had a manufactory. His early education was received at home, after which he entered the Lycée of Upsala, and in 1844 he took his degree as Bachelor of the University of that city. He received a Doctor's degree in 1855, and in the following year was nominated 'Professor agrégé' at the University. In 1859 he became Assistant Professor, and was nominated Observer at the Astronomical Observatory. Finally, in 1878 he was appointed ordinary Professor of Astronomy, and Director of the Observatory as successor to Dr. Svanberg.

In the year 1860 the Observatory of Upsala was furnished with an equatorial refractor by Steinheil, the object-glass of which was 24 centimètres diameter, and of 13 feet focal length. The optical part of the instrument was of high excellence, but all the mechanical part of the mounting was very inferior, and necessitated frequent alterations to render the telescope fit for work. With this instrument Schultz made a large number of valuable observations.

After becoming Director, Schultz caused many important alterations and improvements to be made in the buildings of the Observatory. The openings in the transit-room and the room for the prime vertical instrument were much enlarged. Two

small observatories were erected in the garden for the use of students. By means of some funds given to the Observatory by one of his predecessors and by a friend, as well as by a grant from the Swedish Government, Schultz was enabled to enrich the Observatory with several important instruments, including an excellent clock by Hohwü, two chronographs, a small universal instrument by Bamberg, a Zöllner photometer, a transit instrument and a vertical circle, both made by Repsold, and furnished with objectives of 96 millimètres diameter. With the transit instrument he determined the right ascensions of a large number of stars of the 7th magnitude and above.

In 1888, on reaching the age of 65 years, Schultz resigned his position at Upsala and retired to Stockholm. Everything seemed to promise his enjoyment of many years of repose; but during the winter of 1889–90 he was attacked by the epidemic of influenza which then invaded Sweden, and the recovery from this illness left him with an affection of the heart, from which he succumbed on May 8, 1890.

At the opposition of *Mars* in 1862 Schultz took part in observations organised for the determination of a more exact value of the solar parallax. The observations, which were made with a filar micrometer on the Steinheil equatoreal, were published in the *Jahres-Schrift* of the University of Upsala in 1862. The combination of his observations with those made at Santiago gave a value of 8″·87 for the solar parallax.

Schultz made many observations of planets and comets, but the most important work which he has contributed to astronomy is an extensive series of micrometrical measurements of the positions of nebulæ. The first portion of this work, which is written in English, entitled *Micrometrical Observations of* 500 *Nebulæ*, was published in 1874 in the 3rd series of the *Nova Acta* of the Royal Society of Sciences of Upsala; the remaining portion, containing between 200 and 300 observations, is not yet published, but will shortly appear. "The primary object of the work appears to have been the formation of a catalogue of nebulæ whose right ascensions and declinations should be sufficiently exact to serve for a future determination of their proper motions." The observations were commenced in 1863, and, so far as they are published, were continued until 1874. They consist of determinations by means of a wire micrometer of differences of right ascension and declination between 500 nebulæ and neighbouring stars of sufficient brightness to admit of being conveniently observed on the meridian. The whole number of single measures upon which the results depend amounts to about 12,000. Many difficulties were attendant upon making such observations in the latitude of Upsala, particularly the long twilight at the most favourable seasons, and the brilliant auroræ boreales in the winter. Schultz significantly remarks that "the aurora is in many instances as formidable an enemy to such observations as moderate moonlight." Notwithstanding these

difficulties, the discussion of the observations indicates that the probable errors are very small, and, from the care and skill exercised throughout the work, it has justly been considered as one of the most important and valuable of its kind yet accomplished.

In vol. xxxv. of the *Monthly Notices* Schultz published a "Preliminary Catalogue of Nebulæ Observed at Upsala," in which he gave the mean right ascension and declination for 1865·0 of 512 nebulæ. A catalogue of 440 comparison stars used for the observations was published at Stockholm in the *Bihang till Svenska Vetenskaps Akademiens Handlingar* in 1875.

In the same volume of that publication will be found a complete research on the orbit of the minor planet *Alexandra*, entitled "Normalorter och Oskulerande Element för Planeten *Alexandra* (54)." Besides other contributions to astronomy, Schultz published in 1873 a micrometrical determination of the positions of 104 stars in the cluster 20 $\mathfrak{h}$ viii. *Vulpeculæ*, and in 1875 he contributed to the *Ofversigt* of the Stockholm Academy a paper on Hansen's Theory of Perturbations.

Professor Schultz married in the year 1860 a daughter of the celebrated optician Steinheil, of Munich, who, with their children, two sons and a daughter, survives him.

He was elected an Associate of this Society November 10, 1882.

## Proceedings of Observatories.

The following Reports of the proceedings of Observatories during the past year have been received from the Directors of the several Observatories, who are alone responsible for the same.

### *Royal Observatory, Greenwich.*

The regular meridian observations of Sun, Moon, and planets, and of stars from the Working Catalogue prepared in 1887 have been continued as before, the total number of transits observed during the year 1890 being 6203, and of zenith distances 5978. The month of December was not only severely cold, but practically almost useless for observing; but September and October were fine. The total number of stars observed during the year was 2105.

Arrangements were made in the autumn for determining the variation of personal equation with the magnitude of the star. The magnitudes of stars were altered by a constant quantity by placing a wire-gauze screen in front of the object-glass of the transit circle, and part of a transit was observed with clear aperture, part with obscured. The comparison of the two results gives the difference of Personal Equation for a known change of magnitude. The observations are still in progress, having been seriously interrupted in December.

The mean error in R.A. of Hansen's Lunar Tables, with Newcomb's corrections, as deduced from 102 observations with the transit circle in 1890, is $+0^{s}\cdot020$, agreeing well with the results of previous years since 1883.

Six observations of the horizontal flexure of the transit circle in 1890 gave results $+0''\cdot05$, $+0''\cdot28$, $+0''\cdot43$, $+0''\cdot27$, $+0''\cdot47$, and $-0''\cdot35$. The apparent correction to nadir observation deduced from reflection observations of stars is $+0''\cdot076$. No correction for this discordance or for flexure has been applied.

The thermometers placed in the north and south angles of the transit circle shutter opening during the years 1888 and 1889 indicated an unsymmetrical distribution of temperature during observing hours. To eliminate any residual index error, these thermometers were interchanged in January 1890, and the subsequent readings have confirmed the results obtained in 1888–9, detailed in the last report. There seems to be no doubt

of the asymmetry in distribution of temperature, and its investigation is being continued by further experiments.

With the altazimuth the Moon has been observed in the first and last quarters as before.

Comet *a* 1890 (Brooks) has been observed with the Sheepshanks Equatoreal on 22 nights. A new comet-eyepiece with an accurate position circle has been constructed by Messrs. Troughton and Simms for use with this instrument.

Eleven disappearances and eight reappearances of stars occulted by the Moon have been observed, and 37 phenomena of *Jupiter's* Satellites. The meagre results obtained from the very cloudy eclipse of the Sun on June 17 have been already communicated to the Society.

The 28-inch object-glass, for which the Observatory has been waiting so long, is now nearly finished. Sir H. Grubb reports that the second, third, and fourth surfaces are finished, and that the first surface is about three-fourths polished. Much difficulty has been experienced during the past year in turning the south-east dome, which has been much strained in the course of thirty years, and it is proposed to replace it by an iron-framed dome of larger diameter, which will be better suited to the new 28-inch refractor.

The photographic equatoreal intended for charting the heavens was received from Sir H. Grubb on 1890 March 17 and following days, and, after considerable delay, owing to the number of small alterations requisite, is now completely mounted and ready for work. Unfortunately the recent long-continued bad weather has prevented many star photographs being obtained; but a number of experiments have been made on the best method of imprinting the réseau, on the kind of plates to be used, &c., and such star plates as have been obtained are satisfactory. The apparatus used for measuring the Transit of *Venus* photographs has been modified for experimental use with the chart plates, and with it the errors of the two réseaux received from Prof. Vogel on May 6 are being determined, this work being about half completed for one réseau. It is hoped that the experience gained by using this apparatus will suggest the best form of micrometer to be ultimately adopted.

Mr. Hollis has been occupied with the selection of guiding stars for the plates of the astrophotographic chart. These stars have been selected from the Bonn *Durchmusterung* from Decl. $+60°$ to the north pole. For the zones $+60°$ to $+65°$ the stars have been identified in the recently published Helsingfors Catalogue, and reduced to epoch 1900, and micrometer settings for the guiding telescope computed, the whole being arranged in complete catalogue form. For zones $+81°$ to $+84°$ (both inclusive) the stars have been identified in Carrington's and other catalogues, precessions and secular variations computed for the Carrington stars, and the reduction of places to epoch 1900 is now proceeding.

Observations of the displacements of lines in stellar spectra have been continued, as in former years, for the determination of the motions of stars in the line of sight; 504 measures have been made of the displacement of the F line in the spectra of 44 stars, and 34 measures of that of the *b* lines in the spectra of 9 stars, besides 84 measures of lines in the spectra of Sun, Moon, or planets, as a check on the adjustment of the instrument, and on the general accuracy of the work. Seven measures were also obtained on one night of the position of the chief line in the spectrum of the great nebula of Orion as compared with the less refrangible line of the bright pair of air-lines which are nearly coincident with the nebular line in question.

Photographs of the Sun have been taken with the photo-heliograph on 223 days, and of these 495 have been selected for preservation, including 10 photographs of the partial eclipse of June 17, and 18 photographs, with a double image of the Sun, taken to determine the position of the wires with reference to the parallel of declination. Photographs have been received from India and Mauritius up to 1890 November 19, and there are thus only four days left in the year ending on that date for which no photograph is yet available for measurement.

The revival in the solar activity, first remarked in June 1889, has become more evident in 1890, both in the number of spots observed and in the latitudes in which they are placed. Several fine groups have appeared in the latter half of the year, the group first seen on July 28 and reappearing in the two following rotations being especially noteworthy.

The observations for the longitude of Paris made in 1888 have now been completely reduced, and the definitive results found by the French and English observers are respectively $9^m\ 21^s{\cdot}04$ and $9^m\ 20^s{\cdot}84$. In view of this unsatisfactory discordance (for some account of which see *Monthly Notices*, vol. li. page 155), it seems desirable that the determination should be repeated with interchange of instruments as well as of observers.

Three naval officers have during the past year been instructed in transit observations. Mr. S. Hirayama, of the Tokio Observatory, is at present studying the work and general organisation of the Observatory.

The volume of Greenwich Observations for 1888 was passed for press in May last, and has been distributed. The volume for 1889 is well advanced.

### *Royal Observatory, Edinburgh.*

The committee nominated by H.M. Secretary for Scotland for the consideration of the site and plans for the new observatory now consists of Lord Crawford, Professor Tait, Lord McLaren, Mr. R. McLeod, Queen's and Lord Treasurer's Remembrancer,

and Professor Copeland. During the past year repeated meetings were held, but, contrary to expectation, the new buildings have not yet been commenced. The ground so liberally ceded by the city of Edinburgh has, indeed, been transferred to the Crown, and complete plans of the proposed buildings, prepared by H.M. Office of Works, were laid before the committee as early as June 2. In a slightly modified form these plans were finally submitted by the committee to the Marquis of Lothian. It is greatly to be hoped that they will receive the sanction of the Treasury before the close of the present financial year, as, until the new buildings are erected, no important work can be taken in hand with the beautiful astronomical instruments now at Dunecht.

In March Dr. Becker went to Dunecht to take exact measures of the foundations of the chief instruments, the dome of the equatoreal, &c., in readiness for their removal. On the only two fine moonless nights that occurred during his stay a number of nebulæ were observed with the transit-circle. In the autumn these and former determinations were reduced to the beginning of the year of observation.

The spectroscopic observations of solar light at medium and low altitudes taken on the Barmekin of Echt in the years 1887–89 were completely reduced by Dr. Becker in the spring, and the resulting spectra expressed in ten large drawings, which were reproduced on a smaller scale by photo-lithography. A comprehensive paper on the subject was communicated to the Royal Society of Edinburgh in July, and has since been published in their Transactions. Reprints of this paper have been distributed to institutions and individuals specially interested in the subject. The part of the spectrum thus dealt with extends from W. L. 6024 to W. L. 4861. It is proposed to extend these investigations to the whole spectrum, if possible, at two stations, at one of which the air is highly charged with moisture, the driest accessible climate being selected for the other.

In October and November much time was devoted to erecting, revising, and adjusting the 12-inch Browning-With reflector in a part of the space acquired for the new observatory where it is not likely to be in the way. The reversing transit instrument used in the previous year in testing the site was moved exactly into the meridian of the proposed new transit-house, where it is adjusted to serve as a temporary collimator while the transit-circle is being placed in position. Some arrangement of this kind is the more desirable because there are no screw adjustments to the Y's of the Dunecht transit-circle. When dropped into the prime vertical Y's the reversing transit instrument will serve to orientate the chief façade of the main observatory building. The perfectly exposed position of these huts on a bare hill, together with their distance from the old observatory and the assistants' quarters, forcibly impress the necessity for forthwith commencing the new structures.

Within the year nine numbers of the "Edinburgh Circulars" were sent out, all referring to comets. The printed catalogue of the Dunecht section of the library is now in course of distribution.

The meteorological readings, reductions, and preparation of weather returns for the Registrar-General for Scotland, as well as the distribution of time-signals, have been continued as in former years, under the care of Mr. T. Heath.

### *Royal Observatory, Cape of Good Hope.*

Observations with the transit-circle have been continued regularly throughout the year.

The chief objects of observation have been the Sun, *Mercury* and *Venus*, stars in the list of the Cape Ten-year Catalogue for 1890, stars occulted by the Moon, stars employed in the latitude determinations of the Geodetic Survey of South Africa, comet comparison stars, and stars employed in zones for determining the scale value of the heliometer.

The work accomplished with the transit-circle in 1890 has been as follows:—

| | | R.A. | N.P.D. |
|---|---|---|---|
| No. of observations of ⊙. | Both limbs ... ... ... | 67 | 76 |
| ,, ,, | ⊙. One limb only ... ... | 5 | 1 |
| ,, ,, | Mercury ... ... ... ... | 30 | 28 |
| ,, ,, | Venus ... ... ... ... | 45 | 48 |
| ,, ,, | Azimuth Stars ... ... ... | 410 | |
| ,, ,, | Stars by Reflection ... ... | 8 | 38 |
| ,, ,, | Observations with screens for personal error depending on magnitude | 2524 | |
| ,, ,, | Catalogue Stars ... ... ... | 3628 | 3858 |
| | Total ... ... ... ... | 6717 | 4512 |

The weather has been exceptionally cloudy during the year, and the definition often so bad during the day as to make it undesirable to make observations; hence the comparatively small number of observed transits of the Sun.

It will be seen that the meridian observations include an extensive series of observations for personal error depending on magnitude.

With the zenith telescope 638 pairs of stars have been observed by Talcott's (Horrebow's) method, partly in connection with Kapteyn's method of latitude determination, partly for control of the law of flexure of the transit-circle, and for correction of the northern and southern systems of declination.

This work completes a series of observations which was begun in 1887 on 414 pairs of stars uniformly distributed over the heavens, and so selected that in each pair the times of upper (or lower) culmination of the two stars differ only a few minutes of time, and the difference of their opposite zenith distance does not exceed 10′ of arc. The range of zenith distance is from 2° to 80°. Each pair has been observed at least on six nights. All these stars are included in the list of the Cape Ten-year Catalogue for 1890, and will therefore be connected with all stars to the fifth magnitude south of the Equator, and with all stars in Auwers' *Fundamental Zone* lists, and all stars in the British and American *Nautical Almanacs*, the *Connaissance des Temps*, and the *Berlin Jahrbuch*, which culminate within 80° Z. D. of the Cape.

The following occultations of stars by the Moon have been observed :—

| | |
|---|---|
| Disappearances at the dark limb... ... ... ... | 9 |
| Reappearances at the dark limb ... ... ... ... | 13 |

No observations of comets have been made throughout the year.

A strenuous effort was made to complete the determination of the absolute division errors of the heliometer scales. As mentioned in last report, this work was suspended in February 1889, because Dr. Gill found that, when observing every night and every morning, he could not expose his eyes to the additional strain of making observations for division errors by day. The work was resumed after the *Victoria* and *Sappho* observations in November 1889, and was continued without intermission till its conclusion in the end of February 1890.

Tables have been constructed giving the equivalents of all possible combinations of scale readings in arc, corrected for division error, together with auxiliary tables giving equivalents of the screw readings in arc, with corrections (in arc) for run. These tables render the rigid reduction of the observations exceedingly simple and convenient.

In February and March some additional observations of the distortion zones (mentioned in last year's report) were made, in order to determine whether the radius of motion of the optical centres of the segments is coincident with the focal length of the object-glass. (In other words, to determine whether, in converting observed distances into arc, it is necessary to introduce a term depending on the square of the distance.) A discussion of the observations showed that, within the limits of the probable error of its determination, the term depending on the square of the distance is insensible, but that a much larger number of observations is required to settle the question with an accuracy corresponding to the precision of the determinations of division error. The chief work to which the heliometer has been devoted

during the year has been the triangulation of the *Victoria* comparison stars. The reasons which led to this undertaking are explained in the conclusion of the Report of last year. A programme for the observations was prepared by H.M. Astronomer.

Having regard to the necessary conditions, a programme of observation was prepared requiring 323 observations in all (each of four pointings), which provides for observations of the distance of each pair, from one to five times, with observations of the standard pair of stars before and after each four of the other pairs observed in the course of a night's work. The work was begun on April 12 (i.e. so soon as the stars could be observed for two hours at a sufficient altitude before sunrise), and was continued till November 14, when the stars were too near the Sun for observation at a favourable altitude in the evening twilight. The programme was completely observed twice at the Cape, and all the pairs set down for a single observation were observed three times instead of twice. At Yale the programme was completely observed once, and most of the stars set down for a single observation were observed twice. At Göttingen a series similar to that at Yale has been secured. Thus, in general, each pair has been observed at least five times, and in some cases as many as twenty times, in all, and, as most of the principal stars are connected in the triangulation with from eight to fifteen other stars, there can be no doubt that their ultimate relative places will be fixed with all necessary accuracy.

In December a number of observations were made of *β Orionis*, both east and west of the meridian, to determine whether any error depending on the hour-angle could enter into the investigation of the parallax of that star.

The actual number of observations made with the heliometer during the year is as follows:—

| | Pointings. |
|---|---|
| Observations of Zones ... ... ... ... ... | 132 |
| *Victoria* Triangulation Standards ... ... ... ... | 1320 |
| Other pairs ... ... ... ... ... ... ... | 3756 |
| Observations of *β Orionis* ... ... ... ... ... | 384 |
| Total... ... ... ... ... ... | 5592 |

The mounting of the new photographic equatoreal by Sir Howard Grubb reached the Cape on June 12, and was erected without difficulty by June 21. The object-glasses, réseaux, and dark slides arrived on August 9, and observations for focus were begun the same night. The general mechanical features of the instrument are excellent, but experience has shown some modifications which should be introduced to facilitate speed and accuracy of working. The clock-work and slow motions leave nothing to be desired. There is a slight optical imperfection, which Sir Howard Grubb has undertaken to remove, and the object-

glass will be brought to England for this purpose by H. M. Astronomer.

A number of experiments have been made for determining the best method of obtaining sharp impressions of réseaux.

For the double purpose of practically testing the accuracy of photographic methods and of strengthening the determination of the relative positions of the comparison stars observed with *Iris*, *Victoria*, and *Sappho*, a complete photographic triangulation of these stars has been made with carefully distributed overlapping plates. Each plate, besides a photograph of a particular field, contains a picture of the Standard Stars taken nearly at the same hour-angle as that of the field intended for measurement.

These Standard Stars (nearly 2° apart) therefore provide means for determining the orientation as well as the scale value of the plate. A comparison of the results of the photographic triangulation with the results of the heliometric triangulation of the *Victoria* stars will afford complete data for determining the optical distortion of the photographic field. When this has been done, the reduction of the photographic triangulation of the *Iris* and *Sappho* stars becomes a comparatively easy matter.

The number of photographs secured has been—

| | | | | | | |
|---|---|---|---|---|---|---|
| In the *Victoria* Triangulation | ... | ... | ... | 218 | exposures | |
| „ *Sappho* „ | ... | ... | ... | 282 | „ | |
| „ *Iris* „ | ... | ... | ... | 86 | „ | |
| For various experimental purposes | ... | ... | | 32 | „ | |

In the beginning of the year the U.S.S. "Pensacola," with the American eclipse party, under Professor Todd, visited the Cape. Mr. Preston, of the United States Coast Survey, and Cadet Patton, of the United States Navy, made a complete series of pendulum and magnetic observations. Professor Cleveland Abbe carried out various meteorological investigations at the observatory. Every facility was given to the observatory staff by Professor Todd, and by every member of his party, to examine and in some cases to test their fine collection of astronomical and other instruments. Their visit will be long and pleasantly remembered by every member of the observatory staff.

Mr. Harold Jacoby, assistant at the Columbia College Observatory, and a member of the eclipse party, remained at the Cape to study the practical working of the heliometer. Mr. Jacoby's services were of great value, not only as an observer, but as an excellent computer. He remained at the Cape till August 6.

During the recent tour of His Excellency Sir Henry Loch (H.M. High Commissioner for South Africa) in Bechuanaland and British Zambesia, arrangements were made for exchanging telegraphic signals for longitude with Lieut. Duncan (late R.N.), who accompanied the party. Mr. Duncan's time observations

were made with a sextant and artificial horizon. The results have been reduced, and important corrections of the previously adopted latitudes and longitudes obtained.

Mr. Newdigate, Colonial Government Surveyor, visited the observatory during the month of November for a course of training in astronomical surveying. He is now engaged in important longitude work in British Zambesia, and exchanges signals with the observatory from time to time in the course of his work.

The field work of the Geodetic Survey makes rapid progress. Major Morris, R.E., has completed the measurement of a longitude chain of triangles connecting the southern triangles of Maclear's work with the new system of Geodetic triangles at Port Elizabeth, and is now making steady progress in measurement of a meridian chain of triangles from Port Elizabeth northwards to Kimberley.

A reconnaissance survey for a longitude chain of triangles connecting Maclear's meridian arc with the Port Elizabeth–Kimberley arc, along the parallel of 31° S. latitude, is nearly completed. This arc joins the Kimberley meridian arc near the town of Hanover, and is therefore called the Hanover longitude arc.

The Kimberley meridian arc will be completed by the measurement of a base line at Kimberley in the course of the current year. The accurate measurement of the Hanover arc will immediately follow, and will complete the system of Geodetic triangles in the Cape Colony.

The extension of the Natal meridian chain through the Transvaal has been delayed by the pressing demand for surveys of boundaries and mining areas, but it is hoped that the work will now soon be begun.

The MSS. observations of the late Commander Pullen have been forwarded to H.M. Astronomer by the Hydrographer, and have been completely reduced and prepared for press. The results include accurate determinations of the latitude and longitude of Port Nolloth, Mossamedes, Benguela, St. Paul de Loanda, and St. Thomé, each on at least three nights' work and one night's determination of the longitude of Bonny. Commander Pullen's observations prove to be of the highest excellence. His probable error for a time determination at stations near the Equator from observed altitudes of two stars, one E. and the other W. of the Meridian, amounts to less than $\pm 0^{s}\cdot 03$.

Partial effect has been given by the Lords Commissioners of the Admiralty to the recommendations of H.M. Astronomer with reference to a supply of computers.

A vigorous effort has been made to overtake the arrears of reduction mentioned in last year's Report.

The results of the Cape Meridian Observations of the Sun, *Mercury* and *Venus* to the end of 1889 have been communicated to Professor Newcomb for incorporation in the discussion of the

constants of his new Planetary Tables, and considerable progress has been made in the reduction of the long series of heliometer observations.

But more computing aid is essential for the reduction of the long and important series of observations which have been accumulated at the Cape.

A sum of 100*l.* has been offered by Miss Bruce, through Professor Pickering, and has been gratefully accepted, in aid of the reduction of the observations for Solar Parallax, and of construction of the maps of the Photographic Durchmusterung.

The Meteorological Observations made in the year 1889 at the observatory, together with those taken in different parts of the Colony, have been printed in the Report of the Cape Meteorological Commission.

Professor J. C. Kapteyn has measured definitively 389 negatives of the plates of the Southern Photographic Durchmusterung, covering 8769 square degrees of the sky. This work represents 489,490 observations of about 193,000 stars, or about 63$\frac{7}{8}$% of the whole work.

The reductions of the positions are completed for all the zones 19°–34° and 57½°–90°.

The reductions of the magnitudes for the same zones have been completed once, and an independent duplicate reduction is nearly completed.

The positions of Stone's Catalogue have been reduced to 1875·0 and are entered in the observation books for the zone 19°–34°. The same has been done for Gould's General Catalogue, the Cordoba Zones, Oeltzen's Argelander, and Lalande, for the zones 19°–34° and 57½°–90°.

### *Armagh Observatory.*

The refractor has been used for observations of nebulæ and physical observations of *Jupiter*, but during the greater part of the year the weather was singularly unfavourable for observing.

### *Cambridge Observatory.*

The work done with the transit-circle comprises :—

Four hundred and eighty-three observations for clock correction; 57 direct and 22 reflected observations of *Polaris* above the pole, and 63 direct and 20 reflected observations of *Polaris* below the pole; 630 observations of zone stars; 18 observations of *Mars* near opposition, and 39 observations of the stars selected to be observed with *Mars*; and 4 observations of stars which had been compared with Brooks' Comet, making a total of 1,336 observations.

The nadir point was observed 158 times; and level and collimation each 149 times.

Observations of the solar eclipse of June 17 were completely frustrated by rain and dense clouds: we simply caught a glimpse of it near the end; but lost sight of it again about a minute before the last contact.

In the early part of the year a fresh determination of the intervals of the wires was made from 112 observations of *Polaris* taken in 1889.

The apparent right ascensions and north polar distances are calculated up to the end of this year; the R.A.s and N.P.D.s, referred to the mean equinox at the beginning of the year, are calculated up to the end of 1889. The reduction to epoch is completed for $0^h$ R.A. to the end of 1889; for the other zone stars, in R.A. to the end of 1885, in N.P.D. to the end of June 1887.

Considerable progress has been made in arranging the zone stars in order of right ascension for the catalogue.

The copy for press of the next volume of *Observations* is far advanced, and the earlier sheets are in the hands of the printers; and it is intended to commence almost immediately the preparation of the catalogue for the press.

Thirty-nine observations of *Polaris* made in 1890 up to Oct. 12 and one observation in 1889, each taken direct and reflected, 20 being above and 20 below pole, give for the latitude $52° 12' 51''·60$, precisely the same as that obtained by Professor Challis with the mural circle. The same observations give for the flexure at the pole $+0''·328$. The coefficient of flexure, obtained by the aid of the collimators, and used since the last determination, is $-0''·50$. Supposing, as we have done, that the flexure varies as the sine of the zenith distance, + when south, the flexure at the pole would be $-0''·50 \sin(-37° 47') = +0''·306$, differing only $0''·02$ from the above.

Numerous applications for places of stars contained in our zone have been promptly attended to. The individual results have been found satisfactory.

The places of *Victoria* and *Sappho* and the comparison stars, obtained from the observations in 1889, have been communicated to the Royal Astronomical Society, and are printed in the *Monthly Notices*.

The preparation of the building for the 25-inch refractor, the munificent gift of the late Mr. Newall, of Gateshead, has already commenced, with the valuable co-operation of his son, Mr. H. F. Newall, M.A., of this University. The object-glass has arrived safely at this Observatory.

*Dunsink Observatory.*

At the date of last report the observations of *Sappho* and the comparison stars chosen by Dr. Gill were in progress, and we hoped in the event of fine weather to be able to make these observations complete. In this, however, we were disappointed, as the weather remained obstinately unfavourable all the month of January, until the stars arrived on the meridian too early to admit of useful work on them.

The reduction of the observations had been postponed till the series was complete, as there was some uncertainty with regard to the intervals of the spider lines in the meridian circle, and it was intended to redetermine them from the transits of the stars themselves. The work of reduction was accordingly taken in hand in February, the meridian circle at the same time being used for observing the stars of the proper motion working list referred to in former reports.

This work was interrupted shortly after its commencement by the erection of the greater part of the reflecting photo-telescope presented to the Observatory by Mr. Isaac Roberts. Although the mirror had not been resilvered, nor the photographic parts finished, we pushed on the erection of the rest of the apparatus, intending, by observations with the 5-inch achromatic, which is attached as a "pilot" telescope, to get the instrument into adjustment, and to test the running of the clock and the performance of the slow motion in R.A., which, having been originally designed by Cooke, the maker, for merely optical work, there was reason to fear might prove inadequate for the more delicate requirements of photography. It was soon found, however, that it would be necessary to test the clock more thoroughly by taking photographs with it. The mirror and plate-holder were accordingly inserted in their places in the month of June, and systematic photographic work commenced.

It was, of course, first necessary to go through a good deal of preliminary work with the instrument in order to acquire the requisite skill in this delicate species of observation to qualify one to pronounce on the performance of the clock. It became apparent, however, as these experiments went on that the clock was affected with a periodic error, of great regularity, occurring in a period of 33 secs., and, although careful and repeated attempts were made to trace the error to its source, it was found impossible to localise it.

The slow motion in R.A., too, which was effected by a cord acting on a pair of differential wheels, was found not to be sufficiently smooth to give good results. Accordingly, it was decided to remodel the clock completely, and, instead of conveying the clock-motion through a large number of wheels, to take it almost direct from the spindle, and to put in one of Grubb's latest forms of slow motion in R.A.

This alteration, it is hoped, will effectually eliminate the error, and enable us to proceed with the parallax work, which it is intended to prosecute by the aid of photography.

For the purpose of measuring the plates a micrometer-microscope, similar to the Oxford instrument, has been completed for us during the year by Messrs. Troughton and Simms.

Since the telescope has been dismantled for the alteration mentioned above, and for other requisite changes in some of the minor parts, such as a new eye-end to the "pilot," &c., the reductions of the *Sappho* stars have been completed, and the results sent for publication to the Royal Astronomical Society. They have already appeared in the *Monthly Notices* for January.

### *Glasgow Observatory.*

The operations at the Glasgow Observatory during the past year have been devoted exclusively to a series of observations of stars with the transit-circle, the desirability of which had been suggested by a comparison of the places of the telescopic stars in the Glasgow catalogue with the corresponding star places in Weisse's first catalogue of Bessel. The work is now drawing to a close, and it is expected that in a few months hence the results will be in the hands of astronomers.

### *Kew Observatory, Richmond.*

The ordinary routine of meteorological and magnetical observations has been carried out during the year, and, as usual, large numbers of various scientific instruments have undergone examination.

Sketches of Sun-spots have been made on 198 days, and the groups numbered after Schwabe's method.

Solar and sidereal transits have been occasionally observed as a check on the signalled times.

During the past summer 225 series of observations of the Sun's actinic power have been made with Violle's actinometer, described in the last Annual Report, upon the plan arranged by General Strachey and Mr. Blanford.

By the kindness of Mr. C. Baker, of High Holborn, the Observatory has received the original sunshine-record cards obtained by the late Mr. Rand Capron, F.R.A.S., at his observatory near Guildford, Surrey, during the years 1880 to 1887.

The Winstanley radiograph, deposited at the Observatory in 1880, was recently repaired at the suggestion of Mr. R. H. Scott, and set up on the lawn. Its action is, however, not

considered satisfactory, and it has been decided to return it to the owner.

The swinging of the invariable pendulums at the Royal Observatory, Greenwich, having been completed during the past winter, the apparatus was dismounted and returned to Kew, where it is now stored awaiting further disposal. A paper describing the operations, and giving full details of the values of the vibration numbers obtained at Kew and at Greenwich, has been contributed to the Royal Society by General Walker (see *Phil. Trans.* vol. 181, A, p. 537). The result shows the number of vibrations made by a seconds pendulum in one day to be 0·64 greater at Kew than at Greenwich.

At the suggestion of General Strachey, Chairman of the Meteorological Council, a new departure has been made in the photography of clouds during the past year, with the view of simplifying the operations of determining their height and the velocity of their movements. Two cameras have been rigidly fixed on their stands, with the axes of their lenses pointed directly to the zenith, and photographs are now taken simultaneously of the area of the sky surrounding the zenith within a circle of a radius of about 15°. These photographs are superposed one on the other, so that the two pictures shall appear to coincide, and a simple measurement of the distance between the images of the zenith points, which are marked by intersecting lines on the photographs, gives a means of readily determining the height of the cloud above the surface of the ground. A second measurement made in like manner of the displacement of the zeniths in a second pair of photographs taken after a given interval of time serves to show the rate of travel of the cloud and the direction in which it is moving at the instant of observation. Twenty groups of clouds, giving heights extending from 1½ mile to 8 miles, and having rates of horizontal motion from 5 miles to 64 miles per hour, have been photographed and measured in this manner during the past summer.

The necessary apparatus to enable the examination of photographic lenses for cameras to be prosecuted at the Observatory, with the view of granting certificates to the owners or purchasers of such articles, has been prepared, and it is in contemplation to adopt a system of examination of lenses which shall provide, first, for a comparatively rough or cursory trial which will enable a person to form a general idea of the capabilities of a lens; and, secondly, a more lengthy and careful trial, for which a higher fee will be charged, and which will give full particulars as to the various qualities an acquaintance with which is necessary to possess a full knowledge of the instrument. Captain Abney and other gentlemen have rendered the Committee much assistance in the practical arrangement of the details of this lens testing.

*Liverpool Observatory, Bidston, Birkenhead.*

The general work has been for the most part of a similar character to that during previous years. It has consisted chiefly of observations of stars with the transit instrument for the determination of clock errors; the communication of Greenwich mean time to the port by the firing at $1^h$ P.M. daily, Sundays excepted, of the time-gun on the pier-head of the Morpeth Dock, Birkenhead; the testing in definite and equidistant temperatures, in order to determine their thermal errors, of all chronometers sent to the Observatory. The officers of the Pacific Steam Navigation Company continue to be supplied with tables of the probable rates of their chronometers for the ensuing voyage in each five degrees Fahrenheit from 45° to 95° inclusive.

The meteorological work has been carried on as heretofore. No break has occurred in the records of the self-registering instruments. From the increasing number of applications for extracts from these records they appear to be found of much practical utility, as affording reliable evidence of the state of the weather at definite times.

*Radcliffe Observatory, Oxford.*

During the year 1890 the attention of the observers has been chiefly directed to the completion of the observations required for a General Catalogue of Stars between 90° and 115° N.P.D.

In order, however, to fill up gaps, the places of the stars have been charted, and stars to a much lower magnitude than 7–8 have been inserted, when necessary, in the Working Catalogue. Special double watches have been kept up during the year to hasten the conclusion of the work.

The Sun and Moon have been observed on the meridian at each favourable opportunity. The lunar results are in preparation, and will shortly be forwarded to the Society for publication.

The total number of observations during 1890 amounted to R.A. 3037, N.P.D. 2543.

A discussion of the solar observations made with the transit-circle during the years 1884–1886 shows that the following corrections appear to be required:—

| | 1884. s | 1885. s | 1886. s |
|---|---|---|---|
| Mean correction to adopted R.A. of clock stars | +0·049 | +0·039 | +0·037 |
| Mean correction to N.P.D. observations ... | −0″·256 | −0″·157 | −0″·190 |
| Correction to adopted tabular obliquity ... | +0·260 | +0·166 | +0·450 |

Preparations were made to observe the contacts of the solar eclipse of June 17, but only one observation through thick cloud was secured.

The reductions of the observations made in 1890 are in an advanced state; the star ledger for 1889 is in progress; and the printed volume of results for 1886 has been distributed.

The meteorological work has been continued as usual, and some further experiments on the moisture of the air have been made.

### *Oxford University Observatory.*

Since the communication of the last report of the Oxford University Observatory, the large equatoreal has been thoroughly completed for the purposes of the International Star Chart. The photo-telescope may be regarded as eminently satisfactory and fully adequate for the refined purposes for which it is intended. The camera at the eye-end has been greatly modified in accordance with certain improvements suggested by the Astronomer Royal. A micrometer also, of somewhat elaborate construction, has been added to the refractor for the purpose of allineating it in any required manner with the photo-telescope. Some difficulty has naturally attended this arrangement, inasmuch as it is necessary to place a photographic plate in such a position as to give the images of the stars, referred to the mean equinox of 1900·0. A considerable number of trial plates of the *Pleiades*, as well as of the stars in the zone assigned to the Oxford University Observatory, have been taken to test the accuracy of the adjustments and the efficiency of the equipments provided, and it is believed that the preliminary difficulties attending the project have been overcome.

In order to obtain the magnitudes of the fainter stars up to magnitude fourteen, by direct measurement, rather than by mere estimation, there has been procured from Mr. Hilger a more delicate wedge of neutral glass than has heretofore been constructed. The object of this arrangement is to afford a means of comparison between the photographic and visual magnitudes of very faint stars. Having in view the vast number of these faintly illuminated objects, there has also been devised a simple arrangement for measuring the diameter of star discs with extreme rapidity and sufficient accuracy. The instrument in question is, in fact, nothing more than two lines, engraved on glass, meeting each other at a very small angle. One of these lines is graduated to millimètres, and by means of these divisions the diameters are read off at once. This method has been found practically efficient for the purpose.

Mr. Simms has been consulted in respect of a new instrument for the measurement of the plates taken in the zone of stars referred to. The instrument suggested is of extreme simplicity, with every promise of affording the requisite accuracy, combined with great economy both of labour and time. This economy is also very materially influenced by the admirable

character of the réseaux supplied by Professor Vogel, of the Potsdam Observatory. Experiments have been made which furnish a hope that the photographic plates can be reproduced on paper with great readiness and effect, and it is expected with adequate permanence.

All the above arrangements have unavoidably occupied, to a great extent, the time and attention of the Observatory; nevertheless, the progress of the parallax work with reference to the stars of the second magnitude has proceeded with regularity. The determinations of the parallax of nineteen stars are fully completed, and the necessary observations of the remaining stars of the second magnitude whose parallax is sought (ten in number) have been obtained. Of these ten stars four are fully measured and await computation. Observations are in systematic progress for the determination of parallaxes of $\gamma$ *Draconis*, as well as of the two faint stars of comparison which give a sensible difference in the relative parallax of $\alpha$ *Cephei*. These stars are being observed with the 13-inch photo-telescope for the purpose of observing fainter stars at a greater angular distance from the centre than could easily be obtained on the small plates taken with the De la Rue mirror.

Some experiments were made towards ascertaining the parallax of several of the better-known planetary nebulæ. It was, however, found that the necessary exposures were so protracted that there would be too great an uncertainty in the corrections for refraction to afford a hope of ultimate success. This valuable and interesting investigation I am thus reluctantly compelled to relegate to other observatories possessing larger optical appliances.

In offering this report of the year's work it must not be overlooked that, in combination with original research, a main duty of the director is also to afford instruction to University students. This necessarily consumes a considerable amount of time and attention, and nothing but the efficiency of the two assistants could have enabled him to produce the results specified above.

### *Temple Observatory, Rugby.*

The usual instruction to members of the school has proceeded as heretofore, and although there is not time to teach much, still it is hoped that some will leave school with a taste for some branch of astronomy. Mr. Seabroke has continued his measurements of the motions of stars in the line of sight with a spectroscope having three prisms, one of 60° and two others of 45°, with a collimator of $1\frac{1}{2}$-inch aperture on the 12-inch reflector. Mr. Highton has measured a considerable number of double stars, but owing to his illness nothing has been done in this line during the latter part of the year.

The measures of double stars made during the past four years have been collected and recently published in the *Memoirs* of the Society.

### *Stonyhurst College Observatory.*

In the astronomical department of this Observatory the usual observations of the solar spots and faculæ have been continued without omission of any opportunity for noting their positions and sketching their forms. The collection of drawings made during the last ten years has been under discussion during the year, and it is hoped that the results may soon be presented to the Society. The chromosphere and prominences have not been neglected; but these have suffered more than the spots from unfavourable weather and other untoward circumstances.

The solar spectrometer, constructed by Hilger and furnished with a Rowland grating of 14,438 lines to the inch, has been transferred to a more convenient position for use. A heliostat of very simple and inexpensive make has been mounted on the roof of the spectrometer-room, so as to be completely under the control of the observer. It consists of a short polar axis carrying a plain silver-on-glass mirror at its lower extremity. The mirror has a free motion in declination, and is controlled by a fine flexible wire working against a spiral spring, at the opposite extremities of its declination-diameter. The wire passes through the upper pivot of the polar axis and over a pulley into the observing-room, where it is coiled over a reducing gear for small movements. The second or fixed mirror has been carefully placed with its centre at the point of intersection of the line of collimation of the slit-lens and the produced line of the polar axis. And there is ample room between the fixed mirror and the slit for an objective of 9 feet focal length. A 6-inch objective of 7 feet focal length, by Alvan Clark, has been in use since the beginning of the summer, and the two mirrors have stood the test very well, the solar image on the slit being well defined, with sharp limb and no appearance of multiple images from the glass surface reflections. The mirrors were supplied by Hilger, having been specially ground for the purpose.

The heliostat is driven by a small pendulum clock fixed to the wall inside the observing-room, the connection being made by a light steel endless chain guided by a pair of friction wheels.

The photograms obtained during the summer months give reasonable hope of useful work to be done in the photographic mapping of the spectrum, with the object of watching for any alteration in the metallic lines.

A reflector of the Cassegrainian form is now mounted in place of the Clark refractor, but no experiments have yet been made

with it. It gives a much larger image of the Sun, which may prove more serviceable for the spectra of the spots. And the loss of light is not likely to be any serious drawback, judging from some surprisingly good results obtained without any form of condenser for the solar rays.

A number of experimental photograms of stellar spectra have also been obtained during the year. But progress in this direction has been very slow. The necessity for long exposures, and the unfavourable weather have kept experiments waiting, so that much remains yet to be done before deciding upon the instrument to be used and the class of work that can be usefully adopted.

### *Mr. Common's Observatory, Ealing.*

The weather during the past year has been very unfavourable for observation at Ealing. Advantage has been taken of every available night, but the 5-foot telescope has only been in use 48 nights since March 1890, and only 24 of these were suitable for nebula photography. In all 31 photographs of nebulæ and clusters have been obtained. The principal nebula photographs are *Orion* 6 (one with 2 hours 35 minutes' exposure, and one with 2 hours' exposure on plates stained with erythrosin; the first mentioned is much the best hitherto obtained); the *Dumb-bell* nebula 5 (the best with 110 minutes' exposure on July 24, showing a large amount of detail); M 77, 3 (one with 150 minutes' exposure, showing the spiral structure very clearly); M 99, 2 (with exposures of 2 hours and $2\frac{1}{4}$ hours, with spiral structure clearly shown); M 96, 1 hour; M 88, 1 hour; M 59 and 60, 2 hours 5 minutes; Gen. Cat. 4045, 2 hours; Gen. Cat. 2203, 2207, 2211, 1 hour; and the *Pleiades*, 1 hour, showing nebulæ. Amongst the clusters photographed may be mentioned those of M 2 (four photographs) and of M 5 (four photographs), the latter showing some new variable stars near the cluster; see *Monthly Notices*, vol. l., page 519, June 1890. Photographs of the Moon have been obtained on nine nights during the year, and *Uranus* and its satellites have been photographed on two occasions.

Observations have been made of the satellites and general appearances of *Saturn*, *Uranus*, and *Neptune* whenever possible, the observations of Mimas being communicated to the Society in May 1890, and published in the *Monthly Notices*, vol. l., page 404.

A double-wire micrometer, with position-circle and electric-light illumination, has been made for the 5-foot telescope, and also a star spectroscope (which was supplied at the end of 1890) fitted with special apparatus for watching the slit during the long exposures necessary for photographing the spectra of nebulæ. Up to the present time, owing to bad weather, only preliminary

work on the *Orion* nebula has been possible with the spectroscope. The spectrum of this nebula has been observed on three occasions (the only three possible since November), but no new lines have been detected.

As mentioned in the last report, the figure of the 5-foot mirror is not perfectly satisfactory owing to a slight ellipticity of the star images seen under high magnification, this ellipticity being probably due to the fact that the disc of glass rested in a sloping position for some years. The new 5-foot disc has been obtained from France, and the grinding of this will be proceeded with at once. Both the grinding machines have been kept in constant work. A 36-inch mirror of 11 feet 3 inches focal length has been made for the Science and Art Department, South Kensington, and two 30-inch mirrors of the same focal length have also been finished, one of these being made with a spherical instead of a parabolic curve to be used in the testing of flat mirror surfaces. Another 30-inch parabolic mirror is now in hand and nearly finished. Two 20-inch mirrors of 45 inches focal length have also been finished during the year, and have been thoroughly tested in the 20-inch telescope erected in place of the 6-inch refractor. A series of photographs of the *Pleiades*, the *Dumb-bell* nebula, of various clusters, and several photographs of the *Andromeda* nebula were taken with this telescope during the testing of the 20-inch mirrors, but the photographs have not yet been compared and measured. An instrument for rapidly comparing and measuring photographs, as described in the "Observatory," in August 1890, is almost completed, and will be used for a full examination of these photographs as well as for those taken with the 5-foot reflector.

A long series of experiments on the photographic determination of the reflecting power of silver, speculum metal, and silvered-glass surfaces (prepared by different silvering processes), and on the reflecting and transmitting power of plain glass have been carried on, but are not yet completed. The results will be communicated to the Society as soon as the experiments are concluded. A number of trials have also been made of various silvering processes, and a new process has been adopted by means of which a perfect film of any required thickness can be formed with absolute certainty, and mirrors of any size can be silvered with ease and rapidity.

The scarcity of good nights, partly due to the nearness to London, limits the use of the large telescope very much, and it is in contemplation to remove it to some more suitable position.

### *Mr. E. Crossley's Observatory, Bermerside, Halifax.*

The refiguring of the 3-foot mirror is not yet completed. As in past years the occasional measurement of double stars, the meteorological observations and reports to the Registrar-General,

&c., transits for time, and the observation of the phenomena of *Saturn's* satellites and lunar occultations have formed the principal work of the Observatory. The double-star measures and some other observations are being prepared for publication.

### *Wolsingham Observatory (Rev. T. E. Espin's).*

During the past year the work of sweeping for stars of the third and fourth types has been continued. The weather during the spring was unusually bad, and very little could be done. The few fine nights were mostly taken up with spectroscopic work in connection with the new edition of the Red Star Catalogue. The total number of new third-type stars detected in the year is seventy-six; of fourth-type stars four are believed to have been detected, but three of them are so faint as to leave some uncertainty about their classification. Bright lines have been detected in the variable stars R *Aurigæ* and S *Coronæ*. Special study has been made of the spectra of R *Coronæ* and R *Scuti*, and the results have already been communicated to the Society. The final revision of the proof-sheets of the new edition of the Red Star Catalogue was completed in the spring, and the work has since been published by the Royal Irish Academy. During the month of November two new variable stars were discovered. These are:

| | h | m | s | ° | ′ | |
|---|---|---|---|---|---|---|
| (1) D.M. + 33°470 | 2 | 30 | 22, | + 33 | 47′1 | (1890) |
| (2) D.M. + 53°2684 | 21 | 37 | 6, | + 53 | 49·4 | „ |

The second is a fine red star, with a remarkable third-type spectrum.

In December Miss E. Brooke presented to the Observatory a fine barograph, by Redier, of Paris, a standard barometer, max. and min., wet and dry bulb and grass thermometers, rain-gauge and rainband spectroscope. The library has been enriched by many valuable presents from observatories at home and abroad. The instruments continue in excellent condition.

### *Dr. Huggins' Observatory.*

The chief work during the past year may be arranged under the following heads:—

(1) A re-examination of the position and character of the chief line in the spectrum of *Orion* and some other nebulæ, with results confirming our former conclusions.

(2) Further photographs of the spectrum of *Orion*, which differ from those described in our last report in containing in addition four and probably five of the lines of hydrogen beyond G, and other new lines.

(3) Two photographs of the spectrum of *Sirius*, which show a new group far on in the ultra violet. It consists of six new lines, which have been measured.

(4) An examination of the Wolf-Rayet stars in *Cygnus*, and direct comparisons of these stars with the hydrocarbon flame, sodium, and hydrogen. The blue band was found not to be due to carbon.

(5) An examination of a number of the more characteristic stars of Vogel's class III*a*. A comparison of them with many terrestrial substances. The view taken of them by Dr. Huggins in 1864 was confirmed.

(6) Observations of the character and extent of the continuous spectrum of the Great Nebula in *Andromeda*. Dr. Huggins' suggestion in 1864, that the apparent ceasing of the spectrum in the orange may be due to the falling off of the eye's power for this part of the spectrum, has been found to be the true explanation. With a suitable prismatic arrangement the red end was distinctly seen.

*Rousdon Observatory, Lyme Regis* (*Mr. C. E. Peek's*).

The routine work of the Observatory has been continued. The year 1890 was very favourable for observation except during December, when work was much hindered by abnormally cloudy skies and severe wintry weather. Observations have been made on 161 nights, this being about the average for the last five years. The $6\frac{4}{10}$-inch equatoreal has been employed on observations of variable stars. The working list contains 24 stars, of which 452 observations have been secured. The usual transit observations for time have been made.

*Birr Castle Observatory* (*Lord Rosse's*).

During the past year the work of the Observatory has been in the direction of getting ready for publication the observations of past years rather than in undertaking fresh work at the telescope. The drawings of the "Milky Way" are in the hands of the lithographer, and one of the four plates is ready to be struck off. The other three are in progress.

The results of the measurements of lunar heat during the eclipse of January 28, 1888, are now fully reduced, and will, we hope, be brought out shortly.

Some attention has been given to astro-photography with encouraging results.

The meteorological observations for the London Meterological Office have been made throughout the year as usual.

## *Hong Kong Observatory.*

At the end of 1889 this Observatory lost the services of both assistants. One of them went away on sick leave, and the other obtained a better-paid situation elsewhere. In consequence a part of the work was unavoidably stopped, but the meteorological observations, weather reports, and storm-warnings have been continued as heretofore with the aid of the two Chinese clerks.

A commission, appointed by the Governor to examine into the working of the Observatory, subsequently reported that the staff was insufficient, and recommended an annual vote more than double of what was sanctioned hitherto. They suggested that the staff should consist of a director, three assistants, and three native clerks.

A cable has been laid across the harbour for communication with observers at other ports, and for issuing storm-warnings. The Morse apparatus is worked by two native telegraphists in the Observatory, and a telephone line now connects the station on top of Victoria Peak with the city. The direction and force of the wind is telephoned every three hours during the day-time.

The time-service was stopped during the first half of the year, but the time-ball was dropped during the latter half of the year with the assistance of an electric engineer, who was appointed acting assistant. The tide-gauge has been transferred to the Imperial Maritime Customs of China, and it is intended to work it in course of time in each of the ports along the China coast. The magnetic observations have also been interrupted for some time.

Major-General Palmer, R.E., at present in Japan, who in 1882 wrote the report which subsequently led to the establishment of this Observatory, but which unfortunately was not at once fully carried out, gave valuable information before the Commission and drew up a report explaining the necessity for a larger expenditure, which was adopted by the Commission and printed by order of the Governor. There is no doubt that this will increase the immediate utility of the Observatory, which is of great importance to all who trade in the Chinese seas, as Hong Kong is considered the third port in the British Empire, judging by the tonnage of the shipping by which it is frequented.

*Melbourne Observatory.*

During the year 1890 the meridian work with the transit-circle has been continued as usual, and on the same lines as in 1889.

The great telescope remained dismantled during a considerable part of the year, on account of refiguring and repolishing the mirrors, which was commenced in 1889. At the beginning of last year one mirror was made in a measure fit for work, but the figure was not quite satisfactory. The second mirror was put on the machine in December, and, after continued disappointments and failures, was satisfactorily completed in June, the figure and polish being as good as it appears possible to obtain, and, indeed, leaving little to be desired in either particular. This mirror and its secondary, which has also been repolished, were at once put into position, and the telescope has since been in use for observation. The performance of the great reflector is now certainly better than it ever has been previously. The second mirror (B) also has now been partly refigured, and it is hoped will be in as satisfactory a state as A. The work done with this telescope during the past year has, in consequence of these repairs, been very limited.

All extra-meridian observations have been made with the smaller telescopes, and include spectroscopic survey work and observations of comets.

The usual meteorological and magnetical work has been carried on uninterruptedly during the year, and the intercolonial weather telegraph system now embraces the whole of the coast-line of Australia, as well as a large part of the eastern portion of the interior. Weather charts and forecasts are published in Adelaide, Melbourne, Sydney, and Brisbane, each one for all Australia.

The Melbourne Second General Catalogue of 1211 stars was published in February, and the Monthly Record of Meteorology and Terrestrial Magnetism has been issued up till August last.

Preparations for the approaching work in connection with the photographic star-charting operations have lately demanded attention; catalogues of guide stars have been prepared, many of which will be re-observed with the transit-circle. The astrophotographic telescope and accessories arrived from Dublin on December 29, 1890, and the instrument is now in process of being mounted. Endeavours are being made to secure trial-plates in time to reach Paris by the time the Conference meets in March.

The Board of Visitors in their last report (September 1890) advise the Government to obtain a refracting telescope of 24 inches diameter, to mount on the large reflector as a twin telescope.

The photo-heliograph had for a considerable time been un-

satisfactory in its performance, both as regards permanence of focus and in the exposing slide, and it has been found desirable to make an entirely new arrangement for carrying the secondary magnifier and a new exposing mechanism. These improvements are now completed, and the instrument is in good working order. Owing to these alterations, only sixty Sun pictures have been obtained during the year.

### *Natal Observatory, Durban.*

The work of the Observatory during the past year has been limited by the absence of the director in England for the eight months April to November. In consequence the greater part of the work has been the routine observations required by the daily necessities of the institution.

The work of observing pairs of equi-zenith distance stars for the determination of the latitude of the Observatory has been brought to an end. In all some nine hundred observations of thirty pairs of stars have been secured. It only remains to investigate the exact declinations of the stars used, in order to deduce the true latitude of the Observatory, which forms the second fundamental point of the South African Geodetic Survey.

Considerable progress has been made in the work of comparing, by equi-zenith distances, the declinations deduced from the observations made at the observatories in the northern and southern hemispheres. A revised list of some eighty pairs of stars has been formed, which are observed on every suitable evening.

During the year there has been received the revised comparison of the Greenwich observations for the years 1847 to 1861 with Hansen's *Tables de la Lune*.* The four earlier years, 1847–1850, have been rejected as not being made with the same instrument as those of later years; but the results of the eleven years' observations made during 1851–1861 with the Greenwich transit-circle are being reduced, compared, and discussed in the same manner as those for the sixteen years 1862–1877 in the memoir on the corrections required by Hansen's *Tables de la Lune* in the *Memoirs* of the Society for 1885.

When this work is completed it will afford a continuous comparison of the *Tables* with the Greenwich observations for the thirty-eight years 1851–1888, and the results are sufficiently advanced to show that the corrections deduced will bring Hansen's *Tables* into close accord with the actual place of the Moon, in so far as they will eliminate all the corrections of short periods, which at present give rise to discordances, varying

* *Monthly Notices*, vol. l. Appendix.

in a single lunation by as much as twelve to fifteen seconds of arc.

Some further progress has been made in preparing for publication two elaborate memoirs on the inequalities in the motion of the Moon due to the perturbations of the planets, the first affording an investigation of the theory, and the second a numerical calculation of the value of some thirty-five terms.

### *Sydney Observatory.*

At Sydney the year 1890 has been singularly unfavourable for astronomical work. The rainfall recorded at the Observatory was 81·418 inches, which is, with one exception (1860) with 82·810 inches, the greatest on record. Some measure of this excessive rainfall may be got from the fact that the average at Sydney is 49½ inches; but even this does not indicate the amount of cloud, which was far in excess of the proportion which might have been expected for the rain.

The work accomplished in 1890 may be summarised as follows:—

*The Transit-Circle.*

| | |
|---|---|
| Number of determinations of Collimation ... ... | 306 |
| „ „ „ Level ... ... ... | 417 |
| „ „ „ Nadir ... ... ... | 425 |
| „ „ „ Azimuth ... ... ... | 168 |
| Number of observations of stars in R.A. ... ... ... | 2021 |
| „ „ „ „ N.P.D. ... ... | 576 |

Thirty-nine nights were wholly devoted to observations for determining longitude of places within the colony for the Trigonometrical Survey.

Five hundred and seventy-six stars observed in N.P.D. have been taken with a view to their use in the photographic survey of the heavens. They are for the most part between 20° and 80° south declinations.

The reduction of stars observed in 1888 is finished, and that for 1889 nearly completed.

With the 11½-inch equatoreal only seventy-eight nights were fit for observing; twelve of these were devoted to comet work, and sixty-six to double stars. The work done was as follows:—

| | |
|---|---|
| Measures of angles of position ... ... | 685 |
| „ „ distance... ... ... ... | 794 |

The comets observed were Comet *c* 1890, and D'Arrest's Comet.

The observations of double stars in 1890 are completely reduced and ready for publication.

All the unpublished double-star observations were in March collected and reduced and prepared for publication.

Early in the year the construction of the astro-photographic telescope was completed so far as it could be until Sir Howard Grubb sent the object-glass. This arrived at the end of September, and in November the telescope was completed and ready for work; every available fine night has been used in experiments for determining the focus and other matters connected with it, the weather being very unfavourable for this purpose, as, when it was fine, the definition was almost invariably bad. The photographic focus of the lens is about 0·08 in. inside the visual focus, and the defining quality of the objective seems to be all that could be desired.

The mounting is extremely satisfactory, and the great weight (2 tons) of the moving parts give it a stability and freedom from ordinary tremor which is a great help in photographic work.

In April, as the photographic objective had not arrived, experiments were made with a lens from the photo-heliograph, but it was found to be unsuitable for depicting the Milky Way; one of Dallmeyer's largest portrait lenses was then obtained and mounted on the stand of the astro-photographic telescope, and work begun in taking photographs of the Milky Way. Whole plates, $8\frac{1}{2} \times 6\frac{1}{2}$, were used; these cover $14° \times 10°$ of the heavens. Beginning with $\eta$ *Argûs*, in the centre of one plate, the whole of the Milky Way to $\beta$ *Triangulum Australis* was photographed; another picture was taken of the constellation *Musca*, and three other plates, one covering the bright part in *Sagittarius*, the others in *Ara* and *Norma*.

Photographs have also been taken of *Nubecula Minor*, exposure in this case lasting 8 hours, and of *Nubecula Major*, 7 hours. The latter reveals a decided spiral structure in this object, and five smaller spirals can be traced round the larger one; and in general outline *Nubecula Minor* is very similar to *Nubecula Major*.

Some work has been done in making a general catalogue of coloured stars in the southern heavens for use in discussing star photographs. 1,200 stars derived from all sources have been included, but the work is not yet completed.

The work of selecting guiding stars for the zone to be photographed at Sydney, 42° to 64°, has been almost completed; as was that for the zone originally allotted to Sydney—viz., 34° to 42°, before the change in the zone was announced.

In October an observing station was established on Red Hill, 615 feet above the sea and 11 miles north-west of the present observatory, with a view of testing its fitness for photographic work. Enough has been proved to show that the position is much better than the city for such work; but the weather

has been so unfavourable that no very long exposures have been obtained. One plate of *Nubecula Major* with $3\frac{1}{2}$ hours' exposure approaches that taken in Sydney with 7 hours' exposure; but it is not equal to it. The instrument used is a 6-inch telescope by Grubb, with the Dallmeyer camera bolted on to the telescope. This camera is the same as that previously used in Sydney.

Arrangements have been made to have the large room on the east of the tower, a part of the building in every respect suitable, fitted up as a library, in addition to the rooms already in part used for books. Serial books have been thoroughly examined, and very many pamphlets and works received in paper covers have been bound.

The report of rain, rivers, and evaporation for 1889, together with the general meteorological results for 1888, have been published and distributed, and the latter for 1889 is in the press.

The reporting rain stations in 1889 numbered 1017; in 1890 the number was 1094.

In March a new gas-engine was obtained, and the system of electric lighting, which had previously been confined to the equatoreal, was extended to the north equatoreal, the transit-circle, and the astro-photographic telescope.

Each instrument has its own group of accumulators; but they are all kept together and charged at one time. It is found that there is very great economy as well as convenience in this arrangement. It has not been deemed necessary to apply the electric light to the library or other rooms; but for the telescopes it is indispensable, and in fact makes it possible to do much work that, without it, is almost or quite impossible.

In explanation of the large number of observations of Level and Nadir, it may be stated that it is the practice to determine these every morning at 9 A.M. with the collimation, in order to test the stability of the piers.

### *Mr. Tebbutt's Observatory, Windsor, N.S. Wales.*

There was much cloudy weather during 1890, particularly in the early months of the year. The adjustments of the 3-inch transit-instrument have been as satisfactory as in former years, but the rate of the sidereal chronometer has not been so good. Eight hundred and twenty-nine star transits, including azimuth stars, have been observed for local time. The following extra-meridian observations have been made, chiefly with the 8-inch equatoreal:—

Twenty-four lunar occultations of stars, comprising twenty-four disappearances and three reappearances.

Phenomena of *Jupiter's* satellites, classified thus:—Transit-ingress, I. 3, II. 2, III. 1, IV. 1. Transit-egress, I. 5, III. 1,

IV. 1. Occultation-disappearances, I. 4, II. 2, IV. 1. Occultation-reappearance, I. 1. Eclipse-disappearances, I. 1, III. 1, IV. 2. Eclipse-reappearances, I. 7, II. 4, III. 4.

Eclipse of the Sun partly observed on December 12.

Seventy-six filar-micrometer comparisons of *Ceres* on May 13, 15, 19, 20, 21, 22, 23, 24, 25, 29; thirty-four of *Juno*, on May 19, 20, 22, 25; thirty of *Ariadne*, on July 21, 22, 23, and thirty-eight of *Undina* on September 8, 9, 10. Three square-bar micrometer comparisons of Denning's Comet on October 4, and ninety-nine of D'Arrest's Comet on October 12, 13, 14, 16, 17; November 1, 5, 6.

Measures of the double stars *p Eridani*, Lalande 4219, *γ Centauri*, *h* 4634, *α Centauri*, Brisbane 5784, and *γ Coronæ Australis*. Determinations of the magnitudes of *η Argûs* and R *Carinæ* on many occasions.

The $9^h$ A.M. meteorological observations have been carried on as usual, but the tide observations, owing to the disturbed state of the South Creek from frequent rains, have been discontinued. The meteorological observations now extend over a period of twenty-eight years. All the astronomical and nearly all the meteorological observations have been made by the proprietor. The reductions likewise have almost all been executed by him.

## Notes on some Points connected with the Progress of Astronomy during the Past Year.

### *Discovery of Minor Planets.*

The following fifteen minor planets were discovered in the year 1890 :—

| No. | Name. | Date of Discovery, 1890. | Discoverer. | Place of Discovery. |
|---|---|---|---|---|
| 288 | Glauke | Feb. 20 | Luther | Düsseldorf. |
| 289 | Nenetta | Mar. 10 | Charlois | Nice. |
| 290 | Bruna | 20 | Palisa | Vienna. |
| 291 | Alice | Apr. 25 | „ | „ |
| 292 | Ludovica | 25 | „ | „ |
| 293 | Brasilia | May 20 | Charlois | Nice. |
| 294 | Felicia | July 15 | „ | „ |
| 295 | Theresia | Aug. 17 | Palisa | Vienna. |
| 296 | | 19 | Charlois | Nice. |
| 297 | | Sept. 9 | „ | „ |
| 298 | | 9 | „ | „ |
| 299 | | Oct. 6 | Palisa | Vienna. |
| 300* | | 3 | Charlois | Nice. |
| 301 | | Nov. 16 | Palisa | Vienna. |
| 302* | | 14 | Charlois | Nice. |

Minor planets Nos. 283, 284, and 285, discovered by M. Charlois, at Nice, in 1889, have been named, respectively, *Emma*, *Amelia*, and *Regina*. Minor planet No. 286 has been named *Iclea* by the discoverer, Herr Palisa, of Vienna. It may be pointed out that the names of the discoverers of Nos. 285 and 286, as given in the last Annual Report, should be interchanged, the former being credited to M. Charlois and the latter to Herr Palisa.

* These objects were observed for No. 298. They were afterwards found to be new planets. Meanwhile, Nos. 299 and 301 had in each case respectively been discovered and numbered.

## *The Comets of* 1890.

The distinguishing feature in the history of comets for the past year has been the prolonged series of observations effected by the Lick Telescope. Comet I., 1889 (discovered 1888 September 2), was observed 710 days after its discovery, and a still longer series of observations is expected. Comet II., 1889 (discovered March 31), was observed in August 1890, while Comet V., 1889, whose orbit is especially interesting as suggesting a possible connection between it and Lexell's comet, was recovered after a lapse of eight months.

During the year the following comets have been discovered :—

I. On 1890 March 19, Mr. Brooks, of New York, perceived a nebulous object, which a subsequent observation on March 24 showed to be a comet. It was described as a bright telescopic comet, with stellar nucleus and short, wide tail. The character and position of the orbit were such that the comet could remain visible for some months, and probably is still within the range of the larger telescopes. The orbit does not deviate sensibly from a parabola.

II. Discovered by M. Coggia, of Marseilles, on July 21. The comet, though described as tolerably bright at its discovery, grew rapidly fainter, and, remaining an inconspicuous object on the summer sky, appears to have been soon lost. Parabolic elements represent the observations with accuracy, but there is some similarity between these elements and those of the comet of 1580.

III. Discovered by Mr. Denning, of Bristol, on July 23, in the constellation *Ursa Minor*. It was a faint object in a 10-inch reflector. This comet, passing its perihelion on September 24, was increasing in brilliancy, but it seems to have been always a difficult object to observe. The motion in declination carried the comet rapidly to the south, and observations became impossible in the northern hemisphere. This object was then observed with difficulty at Cordova till November. There is no reason to suspect ellipticity.

IV. A reappearance of the comet of D'Arrest, which was first seen at Lick by Professor Barnard, apparently without any assistance from the ephemeris of M. Leveau. A comparison of the observed places with that ephemeris shows that the prediction of the perihelion passage was about one day in error; but inasmuch as the perturbations of *Jupiter* alone had been taken into account, the agreement is satisfactory. The great southern declination of the comet, coupled with its extreme feebleness,

has made it a very difficult object even for large telescopes.

V. On November 15 M. Zona, of Palermo, discovered a very faint comet, and whose brilliancy was diminishing, having passed its perihelion in the previous July. The orbit, which is probably parabolic, is distinguished by its considerable perihelion distance. It has been pointed out by Dr. Holetschek that the brilliancy of the comet was approximately the same in the previous March as at the time of discovery, and more favourably situated for observing with regard to the Sun. The declination, however, was then south, and the object could only have been observed in the southern hemisphere.

VI. While Dr. Spitaler, of Vienna, was searching for the last-named comet, he detected a faint nebulous object near its reported place. The approximate position and direction of motion proved, however, that it had no connection with Zona's comet, but was a new discovery. Through bad weather this object was lost, but on December 4, being assisted by the slow motion of the comet, Dr. Spitaler again picked it up. This re-discovery was fortunate, as the comet has proved to be one of short period—about six years—and probably has but recently entered the system, since in the latter half of 1887 the comet at the descending node approached so closely to *Jupiter* that it must have undergone very serious perturbation. The orbit is still very uncertain.

It is to be regretted that neither of the two periodic comets, Brorsen's and Denning's, have been seen at their recent return to perihelion. There is no adequate explanation of the non-appearance of the first of these, since the circumstances of its return were favourable for observation, and it was sought for by powerful instruments in the hands of experienced observers. That Denning's comet escaped is not remarkable. The orbit is very uncertain, and, while the comet is intrinsically faint, the probable date of its perihelion passage determined a path unfavourable for observation. W. E. P.

## *The Transits of Venus in* 1761 *and* 1769.

The observations of the transits of *Venus* in 1761 and 1769 have been so repeatedly and thoroughly examined and discussed by so many who were eminently qualified for the investigation, that it might be thought there remained but little opening for arriving at any different values for the solar parallax from these observations than those already published.

The classical work of Encke on the subject was considered to result in the most reliable value of which the observations were capable of affording. But his investigation, like the earlier ones of Lalande and De Ferrer, and the more recent work by Mr. Stone, as well, indeed, as the discussion of the late transits of 1874 and 1882, all depend upon the interpretation to be put upon the phenomena of contact recorded as having been witnessed by the observers.

Conceiving that the numerous observations of 1761 and 1769 were capable, under the light thrown upon these phenomena at the recent transits, of a different interpretation to that hitherto accepted, Professor Newcomb has made a new and complete discussion of those observations, from which he derives a value for the solar parallax differing very widely from that deduced by Encke. This interesting and important investigation has recently been published as part v. of vol. ii. of the *Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac.*

In the introductory portion of the work Professor Newcomb explains the reasons which have actuated him in undertaking the present discussion. The exaggerated opinion of the accuracy with which transits of the inferior planets could be observed has led to a too free rejection of discordant observations, and produced an undue bias in favour of those which were in good agreement. It having been found that the results thus obtained were erroneous to an extent not supposed possible, a tendency has resulted to look upon them as too inaccurate for further discussion. But, admitting a probable error of the observed times of contact ranging from 10 to 30 seconds, he considers that this forms a fair basis from which to judge them, and if the solar parallax derived from them prove of little value, yet the material for the determination of the motions of *Venus* and the Earth would be alone worth the discussion. On the subject of the phenomena of contact the author states the general theory upon which all preceding discussions were founded to be—

"Firstly, that the formation of the thread of light at ingress and its breaking at egress mark the true time of tangency of the dark limb of *Venus* with the bright limb of the Sun.

"Secondly, that a definite interval intervenes between this formation or breaking of the thread of light and the moment known as apparent or geometric contact of the limbs, which interval arises from and depends upon irradiation.

"Neither of these propositions," he remarks, "is a sufficient approximation to the truth." "The time of formation of the thread of light at ingress can be no other than the moment when the thread grew sufficiently strong and well marked to be seen by the observer." Obviously depending upon telescopic power and atmospheric conditions. "The earlier the time when the observer saw the breaking of the thread of light at egress, the later he would note the apparent geometric contact. The

clearer and steadier the air and the sharper the vision, the more nearly the two phases would approach each other, until, under the best conditions, they should come together."

In considering the observations the author divides them into three classes.

(1) Those in which the formation or extinction of the thread of light is stated to have been observed.

(2) Cases in which some phenomenon of contact was noted earlier than the formation of the thread of light at ingress or later than its disappearance at egress.

(3) Observations in which no statement is made from which it can be inferred that one phase rather than the other was observed.

In considering the difficulty of combining such observations, Professor Newcomb was led to adopt Encke's original system of interpretation, which was that the presumption was in favour of the thread of light unless some evidence was shown to the contrary.

That being so, it is certainly surprising that the result of $8''{\cdot}79$ which he obtains for the solar parallax should differ so much from the well-known value $8''{\cdot}571$ obtained by Encke. It is perhaps a little unsatisfactory that the author is not prepared to explain how this great difference comes about. Some suggestions are made as to the possible causes of the discrepancy, such as the fact that at the northern stations the Sun was near the horizon, so that the observed ingress was too late and egress too early compared with the southern. The weights assigned to the observations may prove a possible source of difference. Professor Newcomb does not accept the interpretation of Cook's and Chappe's observations proposed by Mr. Stone which led him to the value of $8''{\cdot}91$. A third source of difference may be the more accurate modern determinations of the longitudes of the stations.

Throughout the investigation, any comparison with Encke's work which might bias the author's judgment has been avoided.

The second chapter of the work is devoted to a citation, with some discussion, of all the recorded observations of the transit of 1761, and, so far as practicable, a copy of the original record pertaining to each separate observation is given. One testimony is rendered to the completeness of Encke's work in collecting observations: the author states that, having desired to proceed independently, he soon found that nothing which he could discover had escaped Encke's scrutiny.

The third chapter gives, in the same manner, the observations of the 1769 transit, of which one interesting section gives a complete transcription of the much-doubted observations of Father Hell, at Wardhus, the mystery of which, however, was satisfactorily cleared up by Professor Newcomb, in a paper published in vol. xliii. of the *Monthly Notices*. From his own

careful examination of Hell's original MS. notes, he concludes that "whatever the sources from which the corrections were derived, the numbers as printed by Hell were all but one or two obtained at Wardhus."

The fourth chapter is devoted to the geographical positions of the stations, in which the longitudes of all stations not determined by modern methods are separately discussed. A table of the adopted geographical positions is appended.

In the fifth chapter the tabular elements to be corrected by observation are discussed, and tabular times of contacts are given for the phases I., II., III., and IV. for both transits at all the stations. In the following chapter the observations are compared with the tabular times. The tabular summary of observations gives, in a very interesting manner, several details: the kind of observation and the phase to which it belongs, the kind of telescope used and its focal length, and the Sun's altitude at the time of observation.

In the formation and solution of the equations of condition, some novelty in treatment is necessitated by having to deal with a collection of observations made under widely different conditions, and therefore of very different moduli of precision.

In such cases Professor Newcomb points out that the method of least squares, as usually applied, will not give the best results. By a graphical process he exhibits the law of the residuals in magnitude for interior contacts. The residuals are classified as if multiples of five seconds, the nearest multiple being assigned. The first column of a table contains the multiples of $5^s$ from $-75^s$ to $+75^s$. Opposite each multiple is printed as many 1's as there are residuals having a magnitude differing not more than two seconds from that multiple. In discussing this table, the conclusion is arrived at that, making no rejection whatever of results on account of discordance, unfavourable conditions, or unskilfulness, the probable error of a single observation is less than $\pm 15^s$. Residuals without the limits $-67^s$ and $+67^s$ are rejected. The questions are discussed of an expression for irradiation and other imperfections of vision, altitude of the Sun, size of telescope, and magnitude of the black drop.

A table gives the estimated numbers expressive of the irradiation at first interior contact.

The considerations of the weight to be assigned to the observations is examined in detail.

In the equations of condition a coefficient is introduced which depends upon the effect of the imperfection of vision, and has a special value for each phase.

The final discussion of the results yields for the solar parallax the value $8''{\cdot}79$, with a mean error of $\pm 0''{\cdot}051$, and a probable error of $\pm 0''{\cdot}034$.

Professor Newcomb concludes this most interesting investigation by a discussion of the position of the node of *Venus*, and gives the following corrections :—

Correction to Le Verrier's latitude of *Venus* at descending node for mean of 1761 and 1769 ... ... ... + 1″·915

and

Correction to Le Verrier's longitude of the node 1765·5 +32″·4

*M. Tisserand's "Traité de Mécanique Céleste," Tome II.*

During the past year has appeared Vol. II. of M. Tisserand's *Traité de Mécanique Céleste*, of Vol. I. of which an account was given two years ago in the Report of the Council. The present volume deals with the forms and the rotations of celestial bodies. The first part of the book is confined to the forms, and this subject is fully dealt with so as to include the results of much recent work. The figures of the Earth, of the Moon, and of *Saturn's* ring are particularly treated of. A chapter is devoted to giving a short account of the geodesical mode of determining the figure of the Earth, and the results which have been derived from it; and this part of the volume closes with Chapter XXI., on the Earth's figure as determined by pendulum observations.

The last part of the work treats of the rotation of the heavenly bodies, especially of the Earth and Moon. Precession, nutation, and the possible changes of the axis of the Earth, and the rotation and libration of the Moon are all treated of; and the volume closes with two chapters on the rotation of a body of variable form, which introduces the effects of geological changes on the Earth, want of rigidity of its crust, secular cooling, tidal retardation, and finally it treats of the effects of lunar and solar attraction on the plumb-line.

M. Tisserand not only gives references to the authors whose researches he embodies or gives an account of, but he gives at the end of each subject a list of works where the student may meet with further information.

M. Tisserand mentions in the preface that he is absorbed in preparing Vol. III., which, therefore, we trust to be in a position to notice in an early Report. J. F. T.

*Recent Researches on the Solar Motion.*

The method by which the amount and direction of the solar motion has recently been discussed by Professor Boss * and by Herr Stumpe † differs in some important particulars from the many determinations of these constants that have already

* A determination of the Solar Motion, by Prof. Lewis Boss, *Astronomical Journal*, Nos. 195, 196.

† Untersuchungen über die Bewegung des Sonnensystems, von Oscar Stumpe, *Ast. Nach.*, Band 125, No. 3000.

appeared. In the first of the two papers under consideration Professor Boss has rested his inquiry on the proper motions of stars confined to a narrow zone whose breadth is only 4° 20′, and whose mean declination is 3° North. This is the zone which, under the general scheme of the re-observation of Argelander's stars, has been assigned to Albany, New York. Two advantages are gained by the employment of stars in a narrow equatorial zone such as that here used. One is, that if slightly incorrect precession constants be employed, the determination of the solar motion will not be affected, supposing the stars to be uniformly distributed throughout that zone. The other advantage is that the stars are very nearly symmetrically arranged with reference to the co-ordinates of that motion. This fact greatly facilitates the solution of the problem by simplifying the expressions used. It is, however, accompanied by the disadvantage that no correction to the precessional constant in declination can be determined.

Another feature in the work of Professor Boss is the large amount of new material introduced into the discussion. Out of about 250 proper motions employed, only 49 are known to have been used in a similar research. The derivation of these new proper motions has necessitated a rigorous discussion of the systematic differences that exist between the various catalogues employed in their determination, and this portion of the work has been undertaken by Professor Boss with very great care, and the resulting proper motions will, no doubt, command confidence. As illustrating the systematic differences that are to be found between catalogues generally accepted as of fair accuracy, it may be mentioned that if the stellar positions given in the zones of Lalande and Bessel, uncorrected to any general system, be compared with modern results, systematic annual proper motions of $0^{s}\cdot005$ in R.A. and $0''\cdot05$ in declination may be expected.

Professor Boss makes no assumption as to the probable distance of the stars as indicated by their proper motion or magnitude, but, after rejecting a few instances of unusually large motion, he groups the remaining stars whose motions exceed $0''\cdot10$ in the arc of a great circle, in order of right ascension, about one hour to each group. The position of the direction of the solar motion is found, first, by solving the equations of condition furnished by stars brighter than the eighth magnitude; secondly, by those fainter than the eighth; and thirdly, in one entire group independent of magnitude. These three solutions furnish the following values of the constants sought:—

| Series. | Mean Magnitude. | No. of Stars used. | Apex of R.A. | Solar Motion. δ | Centennial Solar Motion. |
|---|---|---|---|---|---|
| 1 | 6·6 | 135 | 280°·4 | +42°·8 | 12″·39 |
| 2 | 8·6 | 144 | 285·7 | +45·1 | 13·73 |
| 3 | 7·6 | 279 | 283·3 | +44·1 | 13·09 |

Since there was reason to think that the resulting direction and amount of the solar motion were injuriously affected by the presence of large proper motions, those exceeding 100 seconds a century were rejected, and the remainder (253 in number) formed into one group, with a mean magnitude of 7·7, gave the following result:—

$$\text{R.A.} = 288^{\circ}7 \pm 7^{\circ}2$$

$$\delta = +51'5 \pm 3'2$$

Centennial motion... $10''{\cdot}58 \pm 0''{\cdot}60$

The computations of Herr Oscar Stumpe are based on the proper motions of 1054 stars whose annual proper motions exceed $0''{\cdot}16$ in the arc of a great circle. The stars used have been taken from Bradley's Catalogue, as reduced by Auwers, from Argelander, and from other miscellaneous sources, the whole of the material having been submitted to a searching investigation. The peculiar feature in the treatment is the modification of Airy's equations, necessitated by the addition of a term $(d\,l)$ depending upon a supposed orbital motion of the stars in the plane of the Milky Way. On this hypothesis a variation of the galactocentric longitude of the stars may be considered as real, whilst the alteration of the latitude and radius vector must be attributed to chance errors. As a matter of fact, the solution of the equations of condition showed that the term $(d\,l)$ was zero, and in the results given below has been treated as such.

The stars have been divided into four groups depending on the amount of the annual proper motion, which was thought to offer a surer guide to the relative distances of the stars than could be concluded from their magnitude. The limits of proper motion of each group, and the number of stars employed, is shown below:—

| Group. | Limits of Prop. Mot. | No. of Stars in Group. | Mean Prop. Mot. of Group. | Mean Magnitude. |
|---|---|---|---|---|
| I. | $0''{\cdot}16 - 0''{\cdot}32$ | 551 | $0''{\cdot}23$ | 6·0 |
| II. | $0''{\cdot}32 - 0''{\cdot}64$ | 340 | $0''{\cdot}43$ | 6·7 |
| III. | $0''{\cdot}64 - 1''{\cdot}28$ | 105 | $0''{\cdot}85$ | 6·1 |
| IV. | $1''{\cdot}28$ | 58 | $2''{\cdot}39$ | 6·5 |

The equations of condition founded on each group have been separately solved, thus affording four independent determinations of the amount and direction of the solar motion. The agreement in the resulting co-ordinates is very satisfactory, and the amount of solar motion as determined from each group varies directly with the proper motion, affording satisfactory evidence that the selected criterion of distance—viz., the annual proper motion—was warranted. The results are as follows:—

| Group. | $\alpha$ | $\delta$ | Annual Motion. |
|---|---|---|---|
| | ° | ° | ″ |
| I. | 287·4 | +42·0 | 0·140 |
| II. | 279·7 | +40·5 | 0·295 |
| III. | 287·9 | +32·1 | 0·608 |
| IV. | 285·2 | +30·4 | 2·057 |

In the last column the annual motion is the maximum angular value as viewed from the mean distance of each group.

The result of these and of other recent investigations into the direction of the solar motion has been to indicate a point in the heavens considerably north and east of that assigned in the earlier discussions. It would seem that the direction would be more accurately described as towards *α Lyræ* than to the generally-quoted stars in *Hercules*. W. E. P.

*Schiaparelli's Researches on the Rotation of Venus and Mercury.*

The periods of rotation of the two inferior planets have been determined from time to time by several observers, but never in a satisfactory manner. The researches of Professor Schiaparelli, lately published in the *Rendiconti del R. Istituto Lombardo*, vol. xxiii., and in the *Ast. Nach.*, No. 2944, are therefore of great interest, the more so as the results have been altogether unexpected.

The earliest observer who detected surface markings on *Venus* seems to have been J. D. Cassini. He was inclined to conclude that the planet rotated in 23 *days*, but he expressed himself very guardedly, and pointed out the diffused appearance of the spots, which made the observations very difficult. Many years afterwards his son made out from the same observations and those of Bianchini, that the period of rotation was $23^h\ 20^m$, though Bianchini himself had come to a very different result. Employing various telescopes by Campani, he observed in 1726–27 a number of markings of an apparently permanent character, from which he constructed a complete map, and found the rotation period equal to 24 days and 8 hours. Professor Schiaparelli, in a detailed discussion of all the earlier physical observations of *Venus*, points out that Bianchini himself acknowledged the difficulty of seeing the dark shades, which, according to his drawings, were only visible along the terminator and never in the middle of the illuminated part of the disc. An examination of Bianchini's map (which is reproduced in the *Ast. Nach.*, No. 278) also shows that the seven dark markings distributed along the equator are all similar in appearance, so that they have only resulted from a perfectly arbitrary combination of the drawings, and the theory was never tested by observing the spots when they ought to have appeared at a distance from the terminator.

More weight has generally been attached to the observations of Schröter, who depended less on the faint shades occasionally seen by him than on a truncation of the southern cusp, the changing appearance of which he believed to be irreconcilable with a slow rotation. He determined the period equal to $23^h\ 21^m\ 0^s$, which value, however, as remarked by Schiaparelli, does not represent the alleged changes well. Various observers have subsequently noticed similar irregularities in the shape of the cusps, but nobody after Schröter has attempted to deduce a rotation period from them. A new investigation of this problem by observations of dark markings was made in 1839–41 by De Vico, who made use of ten thousand measures of difference of declination between spots and the north or south limbs of the planet. The results were, however, unsatisfactory, and finally he combined some of the best observations made at the Collegio Romano with two of Bianchini's, and thus found a correction to Schröter's period, making it $23^h\ 21^m\ 21^s{\cdot}9345$.

Professor Schiaparelli remarks that from Jacques Cassini down to De Vico, the period $23^h\ 20^m$ has been maintained by a series of illogical and illusory conclusions, which can only be compared to those by which the imaginary "trepidation" of the equinoxes was upheld for many centuries.

The observations on which Professor Schiaparelli's investigation is founded were made by him with the 8-inch refractor at Milan, between November 5, 1877, and February 7, 1878, when *Venus* was very favourably situated, being at the greatest eastern elongation on December 11. From December 9 and for about a month a dark shade was seen stretching from the southern cusp in a north preceding direction, but more conspicuous were two small oval and very bright spots, separated by a dark band, and situated close to the southern cusp. A similar phenomenon had been seen at Bothkamp in 1871, and one of the two bright spots was in 1877–78 also seen by Holden, Niesten, and Trouvelot. When *Venus* was followed for some hours at a time the shade and bright spots were seen to remain immovably fixed in the position occupied by them at the beginning of the observation, neither could any change be seen from day to day. On December 15 a drawing was made by Professor Holden at Washington eight hours after Professor Schiaparelli had observed the planet, and yet the two drawings place the principal bright spot in the same place. This shows clearly that *Venus* cannot revolve in 23 hours, and it also disposes of Bianchini's period, as the spot, according to this, should have reached the terminator in less than a day and a half. The values found by Bianchini and De Vico for the inclination and ascending node of the equator of *Venus* on the ecliptic are also shown to be quite erroneous, as they would have made the spots describe wide elliptic paths on the visible part of the disc. The Milan observations can only be reconciled with a period of rotation of between six and nine months, round an axis inclined

at most 12°·9 to the orbit of *Venus*, and Professor Schiaparelli therefore naturally concludes that the rotation takes place in 225 days, the period of revolution of *Venus* round the Sun, and that the axis of the planet is very nearly perpendicular to the orbit. These conclusions are shown to be in perfect accordance with observations by Gruithuisen (1813–14), and Denning (1881).*

Encouraged by these important results, Professor Schiaparelli turned his attention to *Mercury*, which planet he has observed from 1881 to 1889, first with the 8-inch, afterwards with the 18-inch refractor of the Brera Observatory, making in all 150 drawings, which show markings far better defined than the fleeting shadows on the surface of *Venus*. Most of the observations were made in 1882–83, when *Mercury* was followed through seven consecutive synodical revolutions; the daytime being found most suitable for observing, as the planet after sunset was too near the horizon to allow magnifying powers above 200 to be used. The planet could be followed throughout its synodical revolution, except for nearly a month about the time of lower conjunction, and for a week at the upper conjunction. The spots could even be well seen when the planet was only 3° from the Sun, with an apparent diameter of 4″ or 5″. As in the case of *Venus*, the spots were always found in the same places, even after a lapse of several days. That the planet does not revolve in six, twelve, or twenty-four hours became evident when it was followed for many hours at a time without exhibiting any change, and Schröter's period of $24^h\ 0^m\ 52^s{\cdot}97$, determined on very slender evidence, similar to that which he made use of in the case of *Venus*, could thus at once be dismissed. A comparison of all the drawings appears to show that the aspect of the spots is always the same in similar positions of *Mercury* with regard to the Sun and the Earth, so that the rotation would take place in 88 days, in which time the planet makes one sidereal revolution round the Sun. All the observations (1882–89) do not exclude the possibility of a difference of $\frac{1}{1000}$ between the two periods, but probably they are identical. The planet's axis seems to be very nearly perpendicular to the orbit. As the rotation is uniform, and the eccentricity of the orbit is very considerable, a libration of 47° in longitude takes place, so that points along an arc of 227° of the equator of *Mercury* can be illuminated by the Sun, while $\frac{3}{8}$ of the surface never receive light from the Sun.

Professor Schiaparelli's paper (which is to be followed by a detailed account of his observations) is accompanied by a map of the visible part of *Mercury*. The spots are chiefly of a streaky appearance, and seem to be of a permanent character; bright spots are occasionally seen, particularly near the north pole,

* Observations made at the Nice Observatory from May 15 to Oct. 4. 1890, fully confirm Prof. Schiaparelli's results. M. Perrotin finds that his observations can only be represented by a period of rotation from 195 to 225 days. (*Comptes Rendus*, Oct. 27.)

which is generally brighter than the regions around the south pole; and this perhaps explains why the latter to Schröter appeared truncated. As the spots are never seen near the limb, the atmosphere would seem to be very dense. J. L. E. D.

*Determination of the Mass of Saturn from Observations of Titan with the Yale Heliometer.*

The mass of *Saturn* obtained by Bessel with the Königsberg heliometer from observations of *Titan*, and that obtained by Prof. Hall with the Washington refractor from observations of *Titan* and *Japetus*, differed considerably. A new determination with the Repsold heliometer at Yale was accordingly undertaken by Mr. Asaph Hall, jun., from observations of *Titan* made by him during the oppositions of *Saturn* occurring in the years 1885–86 and 1886–87, and has been published in the *Transactions of the Astronomical Observatory of Yale University*, vol. i. part ii. During this period the ring was opened out to nearly its widest extent, and *Titan* could be brought quite accurately to the extremities of the major axis of the ring-ellipse. Accordingly, Mr. Hall's measurements were all made in this way, as were most of Bessel's. A complete set of measures consisted of sixteen pointings, symmetrically arranged, including reversion of the scales and of the prism eyepiece—the major axis of the ring-ellipse being kept apparently horizontal by means of the prism eyepiece. The position-angle was read at the same time as the distance. Observations of various zones of stars were made during the progress of the work for the determination and control of the instrumental constants; so that the "scale-value," as well as the division errors of the scales and the other instrumental errors, were determined with the most elaborate care.

From the observed distances and position-angles, referred to the east end and west end of the major axis of the ring-ellipse, the rectangular co-ordinates of *Titan* referred to the centre of *Saturn* were computed, it being assumed that the centre of *Saturn* coincides with the middle point of the major axis of the ring. In the discussion of the measures these rectangular co-ordinates were compared with rectangular co-ordinates computed from Bessel's first determination of the elements of *Titan* as given in the *Ast. Nach.* Bd. xi. page 1, and thus equations of condition were formed, by Bessel's method, the solution of which furnishes corrections to the assumed elements of the orbit.

Using the expressions for the periodic corrections depending on the Sun and for the reduction of the mean elements given by Hermann Struve in *Supplément I. aux Observations de Poulkova*, the Yale mean elements found from the two oppositions, reduced to 1886 May 1·0, Paris mean time, are:—

| | 1885-86. | 1886-87. |
|---|---|---|
| Epoch ... ... | 247° 5′·38 ± 0′·669 | 247° 3′·98 ± 0′·906 |
| Perisaturnium ... | 274 15·02 ± 9·158 | 274 35·42 ± 15·095 |
| Ascending Node | 168 12·84 ± 1·471 | 168 18·13 ± 2·077 |
| Inclination ... | 27 39·42 ± 0·665 | 27 43·03 ± 0·941 |
| Semi-axis Major | 176″·599 ± 0″·0263 | 176″·501 ± 0″·0405 |
| Eccentricity ... | 0·029253 ± 0·0001423 | 0·029359 ± 0·0002250 |

The most important correction to Bessel's elements is that to the Perisaturnium. H. Struve, in the paper referred to above, found a correction of $+50''$ per annum to the motion of the Perisaturnium as given by Bessel. If, however, the difference between Königsberg and Yale be ascribed wholly to error in Bessel's value of the motion, an increase of $+80''$ per annum to that motion is obtained.

The final value of the semi-axis major, found by combining the results of the two oppositions, is $176''{\cdot}570 \pm 0''{\cdot}0243$; the corresponding value of the reciprocal of the mass of *Saturn's* system is

$$\mu = 3500{\cdot}5 \pm 1{\cdot}44.$$

It is shown by H. Struve that the corrected value of $\mu$ found by Bessel from *Titan* should be $3502{\cdot}5 \pm 0{\cdot}77$, while the values found by Struve himself from *Japetus* and *Titan* are respectively $3500{\cdot}2 \pm 0{\cdot}82$ and $3495{\cdot}7 \pm 1{\cdot}43$, all of which are in substantial agreement with the Yale value. Prof. Hall, using the great Washington refractor, found from *Japetus* $3481{\cdot}2 \pm 0{\cdot}65$ and $3481{\cdot}4 \pm 0{\cdot}97$, and from *Titan* $3496{\cdot}3 \pm 1{\cdot}84$ and $3469{\cdot}9 \pm 1{\cdot}49$; the first value in each case being found from observations of differences of R.A. and decl., and the second from observations of distances and position-angles. "Although the difference in the values found for *Titan* might lead one to suppose an error in the value of a revolution of the micrometer-screw, the remarkably good agreement found by the two methods from *Japetus* would not sustain this view, and no reason for the discrepancy is very apparent."

### *Saturn and its Ring.*

During the year which has but recently closed a very valuable monograph on the Saturnian System has reached this country, in the shape of Appendix II. to the *Washington Observations*, 1885. It is entitled "Saturn and its Ring," and contains a detailed account of observations and measurements of the planet made by Prof. Asaph Hall from 1875 to 1889 inclusive, together with his deductions from them; the instrument

employed being the well-known 26-inch refractor of the United States Naval Observatory, with which the satellites of *Mars* were originally discovered. In 1876 a very notable white spot made its appearance near the planet's equator. Notice of this was given to various observatories on the American continent, and the spot was seen by several observers. Prof. Hall selects nineteen observations made in various localities (including, of course, his own) when this spot was actually central on the planet's disc, and from a discussion of them all arrives at the conclusion that the period of *Saturn's* rotation is $10^h\ 14^m\ 23^s{\cdot}8 \pm 2^s{\cdot}30$ mean time. It will be remembered that Sir William Herschel determined the time of rotation to be $10^h\ 16^m\ 0^s{\cdot}4$. Very little that was remarkable, save the spot to which reference has just been made, was seen on the ball of the planet, which near the poles has always seemed of a dull grey with a few faint stripes. Save in 1876, and again during a doubtful interval in 1878, the curvature of the shadow of the planet on the ring always followed the outline of the ball; but during the former (and possibly the latter) year the convexity was turned towards the ball. No notch could ever be detected in the outline of the shadow, nor was any real division ever seen between the dusky ring and the one immediately outside of it. Moreover, Prof. Hall could never perceive the so-called Encke's division of the outer ring as an actual division, "notwithstanding especial pains were taken to do so." Sometimes a kind of marking was noticed, but nothing more. An elaborate series of measurements of the ball and ring of the planet afford results which are probably more accurate than any others which we now possess, but their reproduction is needless here. One very important result must, however, be referred to in conclusion. It is this. In 1851 Struve, discussing the observations of the ring made prior to that date, arrived at the startling conclusion that the ring was seemingly undergoing a secular change, which, by the year 1976, would bring its inner edge into actual contact with the surface of the planet. This theory was adopted by Maxwell and by Hirn in their mechanical investigations into the constitution of the ring. But Prof. Hall, from a comparison of his own measures with those of Bradley, Herschel, Encke, and both the Struves, comes to the conclusion that no change has occurred in the dimensions of the ring-system, at any rate since 1719, so that the catastrophe foreshadowed by Struve is a wholly visionary one. W. N.

*Dr. Hermann Struve's Researches on Saturn's Satellites.*

In No. 2983–84 of the *Astronomische Nachrichten* Dr. Hermann Struve gives an account of some highly interesting preliminary results which he has deduced for the innermost satellites

of *Saturn*. The great optical power of the 30-inch Pulkowa refractor, the steadiness of its mounting, and the goodness of its measuring apparatus allow the observer to measure the mutual positions of *Saturn's* inner satellites, even of *Mimas*, with very great accuracy, and thus to obtain the means of entering upon the proper investigation of their orbits with fair prospects of success. While the observations indicate that the deviations of *Enceladus* and *Dione* from the plane of *Saturn's* equator can be only small, they give for the inclinations of the orbits of *Mimas* and *Tethys* the values 1° 26′ and 1° 5′, and for the annual retrograde motions of the nodes about 365° and 72°. As the sums of these motions of the nodes is approximately equal to double the difference between the mean motion of *Mimas* and twice that of *Tethys*, the consideration of the effect of this approximation to equality upon the elements of the orbits has enabled Hermann Struve to find the probable clue to the puzzling problem of accounting for the variations in the motion of *Mimas*, which were indicated by preceding observations, and which are further proved by the addition of his own. He accounts for these apparent variations by a libration of great amplitude due to the cause indicated, and proceeds to deduce approximate values of the period and amplitude of this libration from the scanty material which is available. As a plausible approximation he assumes 68 years for the period and 97° for the amplitude. The scattered measurements and estimated positions of *Mimas*, made by Bond, 1848–1849 and 1852, and published in 1857 in vol. ii. of the *Annals of the Observatory of Harvard College*, seem to have been overlooked, and will furnish some additional serviceable evidence. But the lack of sufficient trustworthy observations in the past, which, it must be owned, is due to neglect as well as to inadequacy of means, can now only be made good in course of time, and another revolution of *Saturn* will probably have to elapse before the large libration of *Mimas* and the corresponding moderate one of *Tethys* can be worthily determined. From his observations of *Enceladus* Struve finds that the eccentricity of the orbit amounts to about 0·0047, and that the line of apses progresses annually about 120°, which is approximately equal to the difference between twice the mean motion of *Dione* and the motion of *Enceladus*. It remains to be seen whether the inference that this equality is a real one, and that *Enceladus* when in conjunction with *Dione* will also always be near the lower apsis of its orbit, will be confirmed by further observations. It is very satisfactory that we may now reckon upon steady progress in our knowledge of the interesting system of *Saturn*.

A. M.

*The Star Catalogue of the "Astronomische Gesellschaft."*

Three instalments of the extensive and important Catalogue of Stars, to the 9th magnitude inclusive, situated between +80° and −2° declination, for the epoch 1875·0, observed and reduced at various observatories under the auspices of the *Astronomische Gesellschaft*, have been published during the past year. These parts are:—

(1) Third Part.—Zone +65° to +70°, observed at Christiania.
(2) Fourth Part.—Zone +55° to +65°, observed at Helsingfors and Gotha.
(3) Fourteenth Part.—Zone +1° to +5°, observed at Albany, U.S.

(1) The Christiania Catalogue contains 3949 stars between the limits of north declination 64° 50′ and 70° 10′, taken from the *Durchmusterung* and Lalande's *Histoire Celeste.*

The observations for this Catalogue were made in the years 1870 to 1881 with the Ertel 3-foot meridian circle, the telescope of which has an aperture of four inches.

The observations of right ascension were made by the eye and ear method by the late Professor Fearnley, the declination circle being read by means of two verniers by Dr. Geelmuyden. These methods of observation give good results, for the authors deduce a probable error in R.A. of $0^s.054$, and in declination of $0''.54$ for a catalogue place.

The third term of the precession formula for each star is given in the catalogue of this zone.

(2) The observations from which the Catalogue places were formed were made at Helsingfors during the years 1869 to 1876, and at Gotha during the years 1877 to 1880. The removal of Professor Krueger from Helsingfors to Gotha in 1876 did not require any change of instrument, and does not appear to have impaired the unity of the system of observations. At both observatories an 8-foot transit instrument of 66 Paris lines aperture, fitted with an auxiliary arc of 15 inches radius, was used. All the transits were observed by the eye-and-ear method. Professor Krueger finds for the probable error of a single observation—

| | | |
|---|---|---|
| At Helsingfors | ±0ˢ·101 in R.A., and | ±0″·51 in Dec. |
| At Gotha ... | ±0·125 „ | „ ±0·76 „ |

for a mean declination of 60°, and three or four transit threads. In these observations it appeared that the brightness of the star produced no sensible effect on the observed time of transit.

All the stars in the *Durchmusterung*, down to mag. 9·1 in-

clusive, were entered in the Helsingfors-Gotha working list, and all these, with few exceptions, were observed twice at least. Professor Krueger furnishes a table for correcting the secular variations on account of proper motion for 258 stars of the Catalogue for which alone this effect is sensible. A special table for computing the third term of precession, with arguments at intervals of $10^m$ in R.A., and of single degrees in declination, is also given. The total number of stars whose places are given in this Catalogue is 14,680.

(3) The Albany Catalogue gives the places of stars deduced from observations made at the Dudley Observatory, during the years 1878 to 1882, by Professor Boss. The instrument used at Albany was the meridian circle of the observatory of 8 inches aperture. In the zone work the transits of standard stars were observed over fifteen threads, and for these stars all four microscopes were read, whilst for the zone-stars five threads and one microscope were employed. The transits were all observed chronographically.

The probable error of a single observation, for the zone-stars, is $\pm 0^s{\cdot}036$ in R.A., and $\pm 0''{\cdot}55$ in declination, corresponding to the mean declination of the zone. A special investigation on the effect of brightness of a star on the observed time of transit shows that the R.A.s of the Catalogue require the correction

$$-0^s{\cdot}0087\,(M-4)-0^s{\cdot}00166\,(M-4)^2,$$

where M is the magnitude of the star observed.

The position of each star in the Catalogue depends upon at least two observations; and for nearly all stars brighter than 8·0 mag. the number is three or more. Many stars fainter than 9·0 mag., which could readily be observed on account of proximity to a programme star, were included in the work. Various subsidiary investigations are given by Professor Boss, such as comparisons with other catalogues, determinations of proper motions, &c., which serve to make the Catalogue a very complete one. The total number of stars whose places are given in this Catalogue is 8241.

As applying generally to the above Catalogues, it may be remarked that no proper motions have been applied to the stars' places as printed (with the exception of stars of the "Fundamental Catalogue"), but values of the proper motions of many of the stars, some of which have been investigated during the progress of the work, are given in the notes. In addition to the mean places, the Catalogues give the precession and secular variation for each star, the mean epoch of observation, the zones in which the observations are to be found, and the reference to the *Durchmusterung*. These Catalogues are of peculiar importance at the present time on account of their applicability to the work of the International Photographic Survey of the heavens. Those parts containing the zones under-

taken at Kasan (+80° to +75°), Cambridge, U.S. (+55° to +50°), Lund (+40° to +35°), and Leiden (+35° to +30°) may, we believe, be expected to be published in the near future. It is to be hoped that the others will follow without unreasonable delay.

*The Munich Catalogue of* 33,082 *Stars for the Epoch* 1880.

The various zone catalogues of stars observed at the Munich Observatory during the years 1840–1872, reduced to the epoch 1850·0, and published in the *Supplementbände* to the *Munich Annalen*, were considered by Lamont, under whose direction the observations and reductions were made, as provisional only. Lamont projected the formation of a general catalogue, giving the positions of over 33,000 stars for the epoch 1880·0, deduced from some 75,000 observations, resulting from a discussion of the star-places given in the various zone catalogues. This extensive work, however, Lamont did not live to accomplish, and it has now been completed and published by Professor Seeliger, Lamont's successor in the directorate of the Munich Observatory. The catalogue forms Band I. of the *Neue Annalen der K. Sternwarte in Bogenhausen bei München.*

The observations were made with the Reichenbach Meridian Circle of the Observatory, the telescope of which has an object-glass, with aperture of 109 mm., and the circle a diameter of 0·95 m. During the earlier years of observation the transits were observed by the eye-and-ear method, and the circle was read by four verniers; afterwards a chronograph was used, and the circle read by two microscopes. An auxiliary arc was also supplied for reading off small differences of declination for the zone observations. A magnifying power of 110 was used throughout.

For the formation of the general catalogue the various zones have been compared together where they overlap, each, as far as possible, being reduced to the mean of all the rest; and in this way, by successive approximations, the stars in the different zones have been reduced to a homogeneous system. The positions thus formed for 1850·0 have been brought up to 1880·0 by means of Bessel's value of the precession. The places of the standard stars used in the reductions were taken from the ephemerides, published in the *Berliner Jahrbuch*, for the different years of observation.

The general catalogue thus formed gives the places of 33,082 telescopic stars, down to the 10th mag. inclusive, situated between −32° and +24° declination. Unfortunately, the stars are very unequally distributed—a circumstance which, for some purposes, detracts much from the value of the catalogue. Thus in R.A. $3^h-4^h$, there are only 197 stars, whilst in R.A. $19^h-20^h$ there are 8498 stars; these being the extreme cases. Professor

Seeliger has carefully compared the star-places of the Munich Catalogue with those of various other catalogues, and with very satisfactory results. The agreement with the Fundamental Catalogue of the *Astronomische Gesellschaft* is remarkable, and shows that the places of these fainter stars, many of which are not to be found in hitherto published star catalogues, may be used with confidence. Professor Seeliger's work will doubtless prove one of great utility to practical astronomers, especially in the determination of the proper motions of faint stars.

*The Second Melbourne General Catalogue of* 1211 *Stars for the Epoch* 1880.

This Catalogue contains the results of observations made with the old transit circle of 5 inches aperture from the beginning of 1871 to the end of August 1884. The separate results of the observations from which the Catalogue has been compiled have been published in vols. v., vi., and vii. of the *Melbourne Observations*. The great majority of the right ascensions and polar distances of the Catalogue have been corrected for the effect of proper motion; and the polar distances further corrected so as to depend on the colatitude and system of refraction corrections (differing to the north and to the south of the zenith) previously adopted in the formation of the First Melbourne General Catalogue.

The adopted proper motions have been taken from the Catalogues of Auwers, Stone, Newcomb, and Gould; and when not obtainable from these sources have been specially computed—generally from a comparison of the Cape observations, 1829 to 1852, with recent Melbourne places. "Most of these proper motions must be considered as only provisional." They have, however, been used in forming the adopted star places.

In addition to the annual precession, the Catalogue gives the "second term of the precession" (or half the secular variation), and also the "third term of the precession" for each star, as well as the logarithms of the Besselian star numbers in Baily's order. There is also given in the Introduction a table to facilitate the computation of precessions by the rigorous trigonometrical formulæ, for use in the case of stars not far from the pole. It will thus be seen that the Catalogue is a very complete one, and reflects great credit on Mr. E. J. White, the First Assistant at the Melbourne Observatory, by whom it has been reduced and prepared for publication. The stars whose places are given in the Catalogue appear to be of quite a miscellaneous character; a large proportion of them are observable in these latitudes, and will therefore be available for comparison with observations obtained at stations where they culminate at widely different altitudes.

*The Leiden Zone Observations.*

The fifth volume of the *Annalen der Sternwarte in Leiden*, recently published, contains the remainder of the observations of the stars in the zone $30° - 35°$ north declination (the portion of the programme of the *Astronomische Gesellschaft* undertaken at Leiden), the first instalment of which appeared in Band iv. of the same series. The number of observations contained in Band v. is 9954, and in Band iv. 10,395, making a total of 20,349. The number of stars in the working list, occurring within the above-mentioned limits of declination, is 10,250; there therefore remain but 151 observations to complete an average of two observations for each star. There are, besides, some cases in which a third observation is desirable on account of discordance in the results already obtained. These supplementary observations will appear in a subsequent volume.

*Professor Pickering's Photometric Revision of the Durchmusterung.*

The Harvard College Observatory has recently published a further important contribution to the Photometry of the Heavens. Vol. xxiv. of the *Annals* is devoted to results of observations made with the meridian photometer during the years 1882–88.

The present series differs from that known by the name of the *Harvard Photometry* (which was noticed in a previous report), inasmuch as the aperture of the telescopes employed was four inches instead of two, and stars of the ninth magnitude were thus rendered as easy to observe as those of the sixth magnitude with the former instrument.

It will be remembered that the meridian photometer is an instrument provided with two object-glasses, mounted side by side in a fixed position, upon which the light of two stars near the meridian is thrown by means of reflecting prisms or mirrors, while the images thus formed are photometrically compared by polarising apparatus. As they are produced by similar means and viewed upon the same background, the comparison is apparently free from systematic error. The larger instrument was constructed in the year 1882; the two four-inch object-glasses had focal lengths of 57 and 65 inches respectively. The field was 40′ in diameter, and the magnifying power employed was 28.

In the *Harvard Photometry* the brighter stars were compared solely with *Polaris*. In the present observations $\lambda$ *Ursæ Minoris* was selected as the standard star, but in order to avoid any error which might result from a possible variation in its bright-

ness, the results are made to depend upon a series of 100 circumpolar stars, the magnitudes of which were frequently determined with the smaller instrument.

The principal work undertaken with the new instrument, the results of which are now published, was the determination of the magnitudes of a sufficient number of stars in the *Durchmusterung* and distributed with approximate uniformity, to serve as standards of reference for future estimates or measures of magnitude. In the revision of the *Durchmusterung* undertaken by various observatories under the auspices of the *Astronomische Gesellschaft*, each zone extends 10′ north and 10′ south of the limiting declinations. Each star in a narrow zone of 20′ would be observed at least twice at each of two observatories. Consequently there would be four independent estimates of magnitude available for comparison.

It was this fact that determined Professor Pickering to photometrically measure all stars not fainter than magnitude 9·0, in zones of 20′ in width, having their middle parallels at the declinations 0°, +5°, +10°, +15°, &c., to +85°, and, in addition, similar zones at −5°, −10° to −20° were observed.

The volume under consideration contains some miscellaneous measurements in addition to the catalogue of the magnitudes of stars observed in the photometric revision of the *Durchmusterung*.

Some estimate may be formed of this extensive work when we learn that "the total number of series of measurements is 1067, and the number of separate objects observed is 20,982. Four photometric settings were made upon each object, and these were repeated on the average between three and four times. The total number of settings is 267,092." When it is still further borne in mind that about two-thirds of these measures were made by Professor Pickering himself, it is possible to gauge the admirable, unrelaxing energy and skill that characterises the present Director of the Harvard College Observatory.

In the Catalogue the stars are, of course, arranged in zones, giving the *Durchmusterung* number—approximate R.A. and Decl. for 1855—the Bonn estimations of magnitude compared with the present photometric measures—the numbers of the series of observations in which the stars occur. The remaining columns give the residuals corresponding to the separate series, expressed in the same notation as was adopted in the *Harvard Photometry*, and the residuals similarly expressed corresponding to certain estimates of magnitude made concurrently with the measures.

Of the miscellaneous photometric measurements, there is given a catalogue of 3180 *Durchmusterung* stars not included in the above zones. These stars are arranged in order of right ascension for the epoch 1900. The columns give similar details to those in the zone catalogue. Professor Pickering designates the photometric magnitudes of this Catalogue by the letters M.P. (presumably "Meridian Photometry"), in contradistinc-

tion to H.P. ("Harvard Photometry"), employed in the catalogue published in vol. xiv. of the *Annals*.

Measurements were made of 166 variable stars, and the results are given in a separate section of that work. Finally there is given a series of measurements of *Jupiter's* satellites, *Iapetus*, *Uranus*, *Neptune*, and four minor planets, *Ceres*, *Pallas*, *Juno*, and *Iris*.

The volume is a display of an extraordinary amount of work carried out apparently with such high excellence and indefatigable zeal as cannot fail to add further renown to the Astronomical Establishment of Harvard College.

*Dr. Dunér's Determination of the Rotation Period of the Sun.*

During the preparation of his great Atlas of the Solar Spectrum M. Thollon drew attention to the advantages offered by a comparison of solar lines with the telluric lines in their immediate neighbourhood, for the determination of the velocity of the Sun's rotation. The Sun's rotation is, comparatively speaking, so slow that the displacement of the lines in the spectra of the E and W limbs, owing to the approach of the one and the recession of the other, is but small in amount, and when it is sought to compare the spectra of the two limbs together directly, various minute errors assume a grave importance, those arising from an unequal heating of the jaws of the slit being particularly troublesome. When, however, suitably chosen telluric lines are adopted as the reference lines, these sources of error are eliminated, and the measures become more accordant and trustworthy. Dr. Dunér has recently (*Ast. Nach.* No. 2968) published the results of three years' work, in which the speed of the Sun's rotation has been determined by this method, and not merely for the Equator, but for different latitudes up to 75°. The result he deduces shows a close correspondence with the deductions of Carrington and Spoerer from their observations of Sun-spots, with this advantage in favour of the spectroscopic method, that it can be applied to any latitude, whereas Sun-spots are rare above 35°, and practically cease at 40°. A period of $25^{d}\cdot46$ is deduced for the sidereal rotation at the Equator, and $38^{d}\cdot54$ for that at lat. $74^{\circ}\cdot8$; but it must be remembered that a very minute difference in the measures would make a very considerable difference in the rotation period deduced, and especially so for high latitudes. Dr. Dunér gives 0·002 tenthmetres as the probable error of the results of a season; this would correspond to $0^{d}\cdot7$ at the Equator, and to more than 11 days at 75°. So that, though the measures distinctly point to a diminution of angular velocity with increased distance from the Equator, the amount of that diminution, especially in the higher latitudes, is still left open to considerable uncertainty.

The measures were made with a diffraction spectroscope furnished with a Rowland grating, and the lines observed were the solar lines, λ 6301·72 and λ 6302·72, due to iron, and the telluric lines, λ 6302·21 and λ 6302·97, due to oxygen. It would be a work of considerable interest to apply the same method to other regions of the solar spectrum; the group at λ 5975, to which M. Thollon drew attention in the *Comptes Rendus*, vol. xci. p. 368, offering some special advantages.

E. W. M.

*M. Thollon's Atlas of the Solar Spectrum.*

The principal feature of the third volume of the *Annales* of the Nice Observatory is the magnificent Atlas of the Solar Spectrum designed by the late M. Thollon, whose untimely death lends an especial and melancholy interest to this his last and greatest undertaking. Fortunately, although he was not able to delineate the entire spectrum, he lived long enough practically to complete his charts for the part he had commenced upon, and this part is, for the special object he had in view, the most important.

The Atlas as it stands is divided into 33 maps, each about a foot in length, and represents the spectrum from A to *b*. The scale, therefore, is a most ample one, one-tenth mètre at D being represented by five millimètres on the chart, and, the spectrum being prismatic and not normal, one at *b* by nine millimètres. About 3200 lines are shown, of which 2090 are purely solar, 866 purely telluric, and 246 would appear to be due to telluric lines superposed upon solar lines. But in spite of the ample scale of the map, and the extreme care bestowed upon its construction, it could scarcely have attained the standard of character its author hoped for were it not for a further excellence it possesses; for the advance of photography has rendered it possible to supply a map of the entire spectrum with an ease, an accuracy, and a fulness of detail which direct micrometric observation cannot hope to rival. It was M. Thollon's desire, however, not to represent the spectrum under one single aspect alone, but practically under every variety of solar elevation, and of aqueous absorption. This he has secured by a fourfold representation: the first showing the spectrum as obtained from a low Sun, 10° altitude, and the air fairly dry; the second and third with a Sun at 30° altitude, the air in one case being at the point of saturation, and in the other very dry; and lastly the purely solar lines are shown by themselves, so that the spectrum is delineated as it would be seen from a station situated above our atmosphere. To secure this fourfold representation must have entailed an enormous increase in the time and labour

expended on the chart, but the gain to those who will use it will be fully in proportion, and the debt which spectroscopists owe to M. Thollon's memory will long remain a heavy one. But for this feature the Atlas—especially since, as stated above, it is not a normal one—would have been practically superseded before it was published; with it it will, in all probability, long remain a standard work of the highest value.

The engraving of the charts, the execution of which is of the utmost beauty, has been entrusted to M. Legros. E. W. M.

*The Photographic Chart of the Heavens.*

During the past year considerable progress has been made in completing preparations and making preliminary trials with the astro-photographic telescopes. The majority of the observatories participating in the work have their instruments practically ready; and it is to be hoped that at the approaching meeting of the Permanent Committee in March next decision will be arrived at with regard to some of the outstanding questions, so that little further delay need elapse before actually commencing the work.

The fifth number of the *Bulletin du Comité International Permanent pour l'exécution Photographique de la Carte du Ciel* has recently appeared. It contains three papers on the photographic magnitudes of stars by Professor Holden and Mr. Schaeberle; an abstract of M. Lindemann's photometric determination of the star magnitudes of the Bonn Durchmusterung, from the Supplement to the Pulkowa observations; a paper by M. Trépied on the necessity of coming to some understanding as to what is meant by stars of the 9th, 11th, and 14th magnitudes on the photographic plates; and two important papers by the Astronomer Royal.

The Report last year announced the distribution of the zones among the several observatories, as assigned by the Permanent Committee in September 1889. The principle upon which that allotment was made was to assign a zone as near as possible to the zenith of the observatory, so as to minimise the effects of refraction. Mr. Christie points out that at such altitudes the dew-caps of the telescopes would be of little use, and the object-glasses would become dewed. He, therefore, proposes that, save in one or two exceptional cases, no observatory shall photograph a zone at a less zenith distance than about 12°. In a second paper, Mr. Christie deals with the resolutions of the Congress as to the two series of plates, the corner of a plate in one series falling on the centre of a plate in the second series, and he proposes to reduce the number of plates in a zone as we proceed from the Equator to the Poles. In a table, which is subjoined, he gives his proposed disposition of the zones, and the number of plates necessary to be taken by each observatory.

| Observatory. | Latitude. | Declination of Zone. | Number of Plates. |
|---|---|---|---|
| | ° ′ | ° ° | |
| Greenwich | +51 29 | +90 to +65 | 1149 |
| Rome | +41 54 | +64 „ +55 | 1040 |
| Catania | +37 30 | +54 „ +47 | 1008 |
| Helsingfors | +60 9 | +46 „ +40 | 1008 |
| Potsdam | +52 23 | +39 „ +32 | 1232 |
| Oxford | +51 46 | +31 „ +25 | 1180 |
| Paris | +48 50 | +24 „ +18 | 1260 |
| Bordeaux | +44 50 | +17 „ +11 | 1260 |
| Toulouse | +43 37 | +10 „ + 5 | 1080 |
| Algiers | +36 48 | + 4 „ − 2 | 1260 |
| San Fernando | +36 28 | − 3 „ − 9 | 1260 |
| Tacubaya | +19 24 | −10 „ −16 | 1260 |
| Santiago | −33 27 | −17 „ −23 | 1260 |
| La Plata | −34 55 | −24 „ −31 | 1360 |
| Rio | −22 54 | −32 „ −40 | 1376 |
| Cape | −33 56 | −41 „ −51 | 1512 |
| Sydney | −33 52 | −52 „ −64 | 1400 |
| Melbourne | −37 50 | −65 „ −90 | 1149 |

### *The Astronomical Society of the Pacific.*

The great activity in observational astronomy that has of late years been witnessed in the United States has met with its natural result in the establishment, for the benefit of one portion of that wide area, of a society for the advancement and encouragement of the science of astronomy.

The occasion of the solar eclipse of 1889 January 1, brought together many amateur and professional astronomers resident in California, the outcome of which was the founding, a month afterwards, at San Francisco, of the "Astronomical Society of the Pacific." This society was formed under the auspices of the Lick Observatory, and started into existence with all the advantages derivable from proximity to such a finely established institution, controlled by a staff of highly competent astronomers.

Two volumes of publications have already appeared, containing many valuable communications. Among the more interesting papers published in the first volume will be found one on the Helical Nebulæ, by Professor Holden; an important investigation of the Photographic Brightness of the Fixed Stars, by Mr. Shaeberle; and a series of observations of *Jupiter* during the years 1879–1886, by Mr. Barnard. The second volume contains numerous original papers, among which is one of conspicuous

merit by Mr. Keeler, "On the Motions of the Planetary Nebulæ in the Line of Sight."

Though the majority of the communications emanate from Professor Holden and his colleagues at the Lick Observatory, their general high character clearly indicates that the society is pursuing its object in a manner thoroughly worthy of the intentions of its promoters, and so as to form a useful centre for astronomical science in California.

### *Professor Bakhuyzen's Method for the Determination of Absolute Personal Equation.*

Professor Bakhuyzen's description of a personal equation apparatus, and the results obtained by it, is dedicated to the Pulkowa Observatory by the Leiden Observatory, on the occasion of the fifty-year Jubilee 1889 August 19. The zone (80°–90°, Dec. N.) observations undertaken at Leiden being then almost finished, Herr Bakhuyzen thought it would add to their value could he obtain absolute personal equations for the observers. The apparatus devised for this purpose consists first of a fixed lens 82 mm. aperture, which receives light from an artificial star; close to it, and adjusted so that the light from the lens falls on it at an angle of 46° 27′, is a prism whose refracting angle is 13′ 33″. This prism is capable of motion round a horizontal axis in order that its refracting edge may easily be placed vertical. The light next falls on a prism, with a refracting angle of 15′ 51″·5, held in a metal ring, and movable about a vertical axis. A long arm fixed to this ring is moved in a horizontal plane, and as it so moves it rotates the prism, and also passes over three platinum contacts, completing a galvanic circuit at each, and so registering a signal on a chronograph. These contacts can be so adjusted that the signal is registered at the instant the artificial star is bisected by one of the threads in the reticule of the transit-circle. The arm and, consequently, the prism move by clock-work. The length of the arm is 510 mm., and the duration of contact $0^{s}\cdot06$. The principal point, however, is in the great care with which the adjustments were made. To see that the beginning of contact coincided with the bisection by the transit-circle thread, a telephone was adjusted so that the observer could hear the contact and make his bisection. Again, to avoid as much as possible any systematic error, the assistant at the machine also judged of the contact, and bisection was not finally made until both were satisfied. This adjustment was made before and after the observations. It was then questionable whether the registration on the chronograph was coincident with the contact or was retarded. To decide this a microphone was placed at the chronograph and connected with a second telephone, so that by placing one at

each ear the observer could hear both the contact and the strike of the armature. No difference was detected. However, for greater security the bisection was made first by hearing the contact, and then by hearing the strike of the armature. With the aid of mirrors the observations could be made also by reflexion. The observations themselves are given, and the results tabulated. These results agree very favourably with the differential results obtained by the ordinary star observations, and Professor Bakhuyzen thinks they may be applied with some degree of confidence. T. L.

*Variation of Latitude.*

In the years 1884–1885 Dr. F. Küstner, of the Berlin Observatory, in making some observations by Talcott's method for the determination of the constant of aberration, found a puzzling systematic error, which he could not regard as instrumental, and which he characterised as a change in the latitude of Berlin by a considerable fraction of a second of arc. The possibility of changes in the latitude, either periodic or irregular, had been discussed at the meeting of the "Association Géodésique Internationale" at Rome in 1883, when a committee was appointed to consider the question; but Dr. Küstner was the first to publish definite observations claiming to show such a change, if we except inequalities of annual period in observations of N.P.D., which have long been recognised at some of the older observatories, but which have generally been ascribed to meteorological causes.

A further exception might perhaps be made in the case of Greenwich, the latitude of which was supposed some years ago to be undergoing a secular change, but the present Astronomer Royal showed good cause for believing this change to be fictitious (Mem. R.A.S., vol. xlv.).

It is quite possible that the origin of the apparent change at Berlin in 1884–1885, and of those to which we shall presently refer, is meteorological; and this was the view to which Dr. Foerster inclined in bringing the matter before the Association Géodésique in 1888. But the subject was in any case worth serious attention; and it was determined, as a first experiment, to make similar and contemporaneous observations by Talcott's method at Berlin, Potsdam, Prague, and Strasburg, from the commencement of 1889. A comparison of the results obtained at the first three stations shows strikingly sympathetic apparent changes in the latitude, amounting to $0''{\cdot}5$ from crest to trough of a well-defined wave; and it follows that whatever be the cause of these fluctuations, it is one operative over a considerable area. This view is confirmed by an examination of observations at Pulkowa in 1884–1885, which are found to be

affected in the same manner as Dr. Küstner's. If, then, the motion is in the Earth's crust, we must suppose that at least the whole of Europe moves together, though it would be premature to say that the whole globe is affected; and, indeed, as remarked above, the phenomenon may still be meteorological. The next step will be to compare observations in nearly the same latitude and widely different longitudes, as was suggested by M. Fergola in 1883. He gave the following table of pairs of observatories eminently suitable for the purpose:—

| | Difference of Latitude. | Longitude. |
|---|---|---|
| | ′ ″ | h m |
| Cape of Good Hope—Sydney ... ... | 4 22 | 8 51 |
| Santiago—Windsor (N.S.W.) ... ... | 9 47 | 9 14 |
| Rome—Chicago ... ... ... ... | 3 53 | 6 40 |
| Naples—New York (Columbia College) ... | 6 22 | 5 53 |
| Lisbon—Washington ... ... ... | 11 7 | 4 31 |

It is to be hoped that it may be found possible to arrange operations in concert by at least one of these pairs, for the careful carrying out of a very limited programme would go far to settle the important question whether it be that the Earth's axis of rotation and axis of inertia are not sensibly coincident, or that there are changes in the disposition of atmospheric strata sufficient to account for the above facts. It is quite possible that a re-examination of existing material may be sufficient to enable us to choose between the two; but until this choice is made it seems unprofitable to speculate further as to the ultimate meaning of the first alternative. H. H. T.

## Papers read before the Society from February 1890 to January 1891.

1890.

Mar. 14. On some celestial photographs taken with a large portrait lens at the Lick Observatory. E. E. Barnard.

$\gamma$ *Coronæ Australis.* E. B. Powell.

On the proper motion of Groombridge 1830. W. T. Lynn.

Observations of the variable star S (10) *Sagittæ.* J. E. Gore.

A new class of binary stars. Professor E. C. Pickering.

Observations of Comet 1888 (Barnard, September 2), made at the Sydney Observatory with the $11\frac{1}{2}$-inch equatoreal and filar micrometer. Communicated by H. C. Russell.

On a method of obtaining the error of a chronometer by equal altitudes of two stars on opposite sides of the meridian. Commander A. M. Field.

A simple method of obtaining an approximate solution of Kepler's equation. A. A. Rambaut.

On the parallax of double stars. A. A. Rambaut.

Observations of phenomena of *Jupiter's* satellites at Windsor, New South Wales, in the year 1889. John Tebbutt.

Photograph of the clusters 33 and 34 H VI. *Persei.* Isaac Roberts.

Suspected variability during short periods in certain stars in *Orion.* Isaac Roberts.

Further note, with a correction, on the spectrum of the Sun-spot of June 1889. Rev. A. L. Cortie.

Some experiments relating to the method of obtaining the coefficient of absorption of the wedge photometer. E. J. Spitta.

Ephemeris for physical observations of *Jupiter*, 1890. A. Marth.

Observations of the Moon made at the Radcliffe Observatory, Oxford, during the year 1889, and a com-

parison of the results with the tabular places from Hansen's Lunar Tables. E. J. Stone.

April 11. Fifth Catalogue of micrometrical measures of double stars made at the Temple Observatory, Rugby. G. M. Seabroke, A. P. Smith, and H. P. Highton.

Discovery of Comet Brooks, 1890. W. R. Brooks.

Photograph of stars in the region of Tycho's *Nova*. Isaac Roberts.

A mechanical theory of the solar corona. J. M. Schaeberle.

On the Nautical Almanac. Lieut.-Gen. J. F. Tennant.

Note on the apparent star places of the Nautical Almanac. H. H. Turner.

Note on the Sun-spots of 1889. E. W. Maunder.

May 9. On the proper motion of three stars. W. T. Lynn.

Observations of the planets *Victoria* and *Sappho*, made with the Cambridge transit-circle in the year 1889. Communicated by Professor J. C. Adams.

The apparent projection of stars upon the bright limb of the Moon at occultation, and similar phenomena. George Davidson.

On the orbit of $\delta$ *Cygni*. J. E. Gore.

Totality of the eclipse of 1889 December 22. Professor D. P. Todd.

Comparison of the right ascensions of clock stars in the Greenwich Ten-Year Catalogue for 1880 with the Fundamental Catalogues of the American Ephemeris and the Astronomische Gesellschaft. Professor S. Newcomb.

A revolving diagonal, with combined total reflection and solar prism. W. Schooling.

Mean areas and heliographic latitudes of Sun-spots in the year 1889, deduced from photographs taken at Greenwich, at Dehra Dûn (India), and in Mauritius. Communicated by the Astronomer Royal.

Observations of Comet *a* 1890 (Brooks), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Notes on reflecting telescopes, and on the making of large discs of glass for them. A. A. Common.

Observations of *Mimas*, 1890. A. A. Common.

Ephemeris for physical observations of the Moon, 1890 July 1 to December 31. A. Marth.

The Jovian evection. E. Nevill.

June 13. The star-places of the Second Melbourne General Catalogue for 1880. A. M. W. Downing.

On star-correction tables. W. H. Finlay.

On the variable star U ("Nova") *Orionis*. J. E. Gore.

On a coming conjunction of a remarkable dark spot

on *Jupiter* with the red spot, and the relative altitude of these objects. A. Stanley Williams.

Comparison of the Greenwich Ten-Year Catalogue with the Williamstown right ascensions of polar stars for 1885. Professor T. H. Safford.

Corrections to the elements of the orbit of *Juno*. A. M. W. Downing.

On the verification of the constants employed in the Uranometria Nova Oxoniensis. Professor C. Pritchard.

On the computation of the equation of the centre in elliptical orbits of moderate eccentricities. A. Marth.

A simple solution of Kepler's problem. A. Marth.

Observations of Comet *a* 1890 (Brooks), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Note on some variable stars near the cluster 5 M. A. A. Common.

Note on the scaling of Dr. Spitta's wedge by means of photography. Captain W. de W. Abney.

Nov. 14. On the real and apparent variations of the latitude of Greenwich. Professor F. Folie.

On an electrical control for driving clocks. H. C. Russell.

On the correction of micrometric measures for refraction. H. Jacoby.

On a possible cause for lunar libration other than an ellipsoidal figure. S. E. Peal.

Observations of Comet *a* 1890 (Brooks), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

The red spot on *Jupiter*. J. E. Keeler.

Two auxiliary tables for the solution of Kepler's problem. A. Marth.

Ephemerides of the satellites of *Saturn*, 1890–91. A. Marth.

Ephemeris of the satellite of *Neptune*, 1890–91. A. Marth.

Spectroscopic notes and queries. Rev. A. L. Cortie.

Observations of the spectra of Sun-spots in the region B–D, made at the Stonyhurst College Observatory in the years 1882–89. Rev. A. L. Cortie.

On the orbit of 99 *Herculis*=Alvan Clark 15. J. E. Gore.

Note on stationary or long-enduring meteor radiants. W. H. S. Monck.

On some celestial photographs recently taken at Sydney Observatory (with appendix). H. C. Russell.

Observations of the variable star R *Carinæ*, from November 1886 to June 1890. John Tebbutt.

Observations of comets made at the Orwell Park Observatory in the years 1889–90. J. I. Plummer.

Preliminary note on the duplicity of *α Lyræ*. A. Fowler.

On the variation of the spectra of R *Coronæ* and R *Scuti*, and on the spectrum of R *Aurigæ* and R *Andromedæ*. Rev. T. E. Espin.

Some experiments relating to the photometric comparison of points of light with objects of sensible area. E. J. Spitta.

Note on the spot-groups of 1888. E. W. Maunder.

On a mechanical method of describing a parabolic curve. R. Inwards.

Comparative photographs of the high Sun and low Sun visible spectra, with notes on the means of photographing the red end of the spectrum. F. McClean.

Photograph of the A line in the solar spectrum. G. Higgs.

Note on the spot-group of 1890 August 25–September 5. E. W. Maunder.

Observations of the solar eclipse of 1890 June 16–17, made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Dec. 12. Note on some celestial photographs taken at the Sydney Observatory. H. C. Russell.

New nebulæ. W. F. Denning.

Note on Hind's variable nebula in *Taurus*. S. W. Burnham.

Ephemerides of the satellites of *Saturn*, 1890–91 (concluded). A. Marth.

Elements and ephemeris of Zona's comet. J. R. Hind.

1891.

Jan. 9. Observations of the planets *Victoria* and *Sappho* made with the meridian-circle at Dunsink. A. A. Rambaut.

Remarks on Mr. Fowler's paper on the duplicity of *α Lyræ*. Professor H. C. Vogel.

The proper motion of H 1968. S. W. Burnham.

Photographic evidence of variability in the nucleus of the great nebula in *Andromeda*. Isaac Roberts.

Mr. Roberts's new Observatory on Crowborough Hill, Sussex. Isaac Roberts.

A theory of the cause of gravitation founded upon the dynamical theory of heat. J. G. Vine.

A list of published lunar sketches and photographs, arranged according to the Sun's position. A. Marth.

Spectroscopic results for the motions of stars in the

line of sight, obtained at the Royal Observatory, Greenwich, in the year 1890. No. XIV. Communicated by the Astronomer Royal.

Note on the recent determination of the longitude of Paris. H. H. Turner.

A comparison between the Greenwich lunar observations, 1887, and Hansen's Tables, uncorrected and corrected, for the change in the unit of mean time introduced in the year 1864, and with Hansen's Tables as modified by Professor Newcomb and Mr. Stone. E. J. Stone.

List of Public Institutions and of Persons who have Contributed to the Library &c. since the last Anniversary.

Her Majesty's Government in Australia.
Her Majesty's Government in India.
The Lords Commissioners of the Admiralty.
The Italian Government.
The Norwegian Government.
British Association for the Advancement of Science.
British Astronomical Association.
British Horological Institute.
Camera Club.
City of London College.
Geological Society of London.
Meteorological Office.
Photographic Society of Great Britain.
Physical Society of London.
Royal Geographical Society.
Royal Institution of Great Britain.
Royal Meteorological Society.
Royal Observatory, Greenwich.
Royal Society of London.
Royal United Service Institution.
Society of Arts.
University College, London.
Zoological Society of London.
Belfast Natural History and Philosophical Society.
Birmingham Philosophical Society.
Bristol Museum and Library.
Cambridge, Clerk Maxwell Memorial Committee.
Cambridge Observatory.
Cambridge Philosophical Society.
Dublin, Royal Irish Academy.
Dublin, Royal Society.
Edinburgh, Royal Observatory.
Edinburgh, Royal Society.
Kew Observatory.
Leeds Philosophical and Literary Society.
Liverpool Astronomical Society.
Liverpool Literary and Philosophical Society.

Liverpool Observatory.
Manchester Literary and Philosophical Society.
Oxford, Clarendon Press.
Oxford, Radcliffe Observatory.
Oxford University Observatory.
Rugby School Natural History Society.
Stonyhurst College Observatory.
Amsterdam, Royal Academy of Sciences.
Australasian Association for the Advancement of Science.
Batavia, Royal Society of Natural History.
Berlin, Physical Society.
Berlin, Royal Prussian Academy of Sciences.
Berlin, Royal Observatory.
Berlin, Royal Prussian Geodetic Institute.
Berne University.
Bombay Branch of the Royal Asiatic Society.
Bordeaux Observatory.
Bordeaux, Society of Physical and Natural Sciences.
Boston, American Academy of Arts and Sciences.
Brisbane, Queensland Branch of the Royal Geographical Society of Australasia.
Brussels, Royal Observatory.
Buda-Pesth, Hungarian Academy of Sciences.
Buenos Ayres, Argentine Meteorological Office.
Calcutta, Asiatic Society of Bengal.
Cherbourg, National Society of Sciences.
Cincinnati Observatory.
Coimbra Observatory.
Copenhagen, Royal Academy of Sciences.
Cordoba, Argentine National Observatory.
Cracow, Academy of Sciences.
Delft, Polytechnic School.
Dijon, Academy of Sciences, Arts and Letters.
Geneva, Society of Physics and Natural History.
Göttingen Observatory.
Göttingen, Royal Society of Sciences.
Haarlem, Teyler Museum.
Halle, Leopold-Caroline Academy of Naturalists.
Harvard College Astronomical Observatory.
Helsingfors, Geographical Society of Finland.
Helsingfors, Society of Sciences of Finland.
Hong Kong Observatory.
International Geodetic Association.
Italian Meteorological Society.
Italian Society of Sciences.
Japan, Seismological Society.
Kiel, Royal Observatory.
Leghorn, Technical and Nautical Institute.
Leipzig, Astronomical Society.
Leipzig, Royal Saxon Society of Sciences.

Leyden Observatory.
Lick Observatory of the University of California.
Madrid Observatory.
Madras Observatory.
Manilla Meteorological Observatory.
Mauritius, Royal Alfred Observatory.
Melbourne Observatory.
Melbourne, Royal Society of Victoria.
Mexico, Society "Antonio Alzate."
Milan, Royal Observatory.
Moncalieri Observatory.
Montreal, Royal Society of Canada.
Moscow, Imperial Society of Naturalists.
Moscow Observatory.
Munich, Royal Bavarian Academy of Sciences.
Munich, Royal Observatory.
Naples, Royal Academy of Sciences.
Natal Observatory.
Ottawa, Canadian Meteorological Office.
Paris, Academy of Sciences.
Paris, Bureau of Longitude.
Paris, General Depôt of Marine.
Paris, International Committee of Weights and Measures.
Paris, Mathematical Society of France.
Paris Observatory.
Paris, Philomathic Society of France.
Paris, Polytechnic School.
Philadelphia, American Philosophical Society.
Philadelphia, Franklin Institute.
Prague, Imperial Observatory.
Pulkowa Observatory.
Rio de Janeiro Observatory.
Rome, Italian Spectroscopic Society.
Rome, Pontifical Academy *dei Lincei*.
Rome, Royal Academy *dei Lincei*.
St. Petersburg, Imperial Academy of Sciences.
San Fernando Observatory.
San Francisco, Astronomical Society of the Pacific.
San Francisco, University of California.
Sydney, Government Observatory.
Sydney, Royal Society of New South Wales.
Tacubaya Observatory, Mexico.
Tasmania, Royal Society.
Tiflis, Physical Observatory.
Toronto, Canadian Institute.
Toulouse, Academy of Sciences.
Turin, Observatory of the Royal University.
Turin, Royal Academy of Sciences.
Upsala, Royal Society of Sciences.
Vienna, Imperial Academy of Sciences.

Virginia University, Leander McCormick Observatory.
Washburn Observatory, Wisconsin.
Washington, Office of the American Ephemeris.
Washington, Smithsonian Institution.
Washington, United States Coast and Geodetic Survey.
Washington, United States Naval Observatory.
Washington, United States Signal Office.
Yale University, Astronomical Observatory.
Zurich, Central Meteorological Institute.
Zurich, Natural History Society.
Zurich, Swiss Geodetic Commission.
Editors of the "American Journal of Mathematics."
Editors of the "American Journal of Science."
Editor of the "Astronomical Journal."
Editor of "l'Astronomie."
Editor of the "Astronomische Nachrichten."
Editor of the "Athenæum."
Editors of the "Bulletin des Sciences Mathématiques."
Editor of "Engineering."
Editor of the "English Mechanic."
Editor of "Himmel und Erde."
Editor of "Le Galilée."
Editor of "Knowledge."
Editor of "Die Naturwissenschaftliche Rundschau."
Editor of "Die Naturwissenschaftliche Wochenschrift."
Editors of the "Observatory."
Editor of the "Sidereal Messenger."
Editor of "Sirius."

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Señor V. Ventosa.
Prof. H. C. Vogel.
Herr C. L. Weyher.
Prof. W. C. Winlock.
Dr. R. Wolf.
Herr A. Wolfer.
Prof. C. V. Zenger.

The meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

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*Vice-Presidents.*

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E. J. STONE, Esq., M.A., F.R.S., Radcliffe Observer.

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W. H. M. CHRISTIE, Esq., M.A., F.R.S., Astronomer Royal.
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